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CONTENTS

Sour scab of citrus in Florida, and its prevention ..... J. G. Grossenbacher 125
Cucumber mosaic disease ..... W. W. Gilbert 143
A new infectious mosaic disease of cucumber ..... S. P. Doolittle 145
Experiments with the cucumber mosaic disease ..... I. C. Jagger 149
Further studies in the rôle of insects in the dissemination of fire blight bacteria,
V. B. Stewart and M. D. Leonard 155
Note on apple root-rot in Virginia ..... C. H. Crabill 159
A troublesome disease of winter tomatoes ..... J. E. Howitt and R. E. Stone 163
Resistance in tobacco to the root-rot disease ..... James Johnson 167
An outbreak of white pine blister rust in Ontario,
J. E. Howitt and W. A. McCubbin 183
Preliminary studies on the resistance of Prunus to artificial inoculation with Bacterium tumefaciens ..... Clayton O. Smith 189
Reviews 199
Phytopathological notes 203
Report of the seventh annual meeting of the American Phytopathological Society 209
Literature on American plant diseases 213

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PHYTOPATHOLOGY

VOLUME VI NUMBER 2

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SOUR SCAB OF CITRUS IN FLORIDA, AND ITS PREVENTION

J. G. GROSSENBACHER

WITH FOUR FIGURES IN THE TEXT

Sour scab is a disease of the leaves, twigs and fruits of certain varieties of Citrus having a strongly acid sap in their actively growing portions. On account of this characteristic the writer favors the term sour scab rather than "lemon" scab, a name given the disease by growers when the lemon was the chief commerical variety in Florida affected by the malady. Sour orange (*Citrus aurantium* var. *amara*), lemon (*C. medica* var. *Lemon*), citron (*C. medica* var. *genuina*) and so forth, are very susceptible to the disease and, under conditions that frequently recur in Florida, most commercial varieties of grapefruit (*C. decumana* var. *pomelo*) except perhaps Triumph, are apparently equally subject to it. At present sour scab in Florida is of most economic importance in its relation to the growing of grapefruit.

This disease is most commonly evident by the distorted appearance of leaves and by the warty, misshapen fruits. Conical elevations having grayish brown tips are usually abundant on young leaves and fruits that are severely affected. Some portions of the diseased leaves seem to grow faster than others and thus result in distortions. As the season advances most of the warty protuberances on grapefruit flatten out somewhat and their tops become more or less covered with dark-gray, flaky scabs. The warty roughenings that remained flat are often eventually wholly covered by those scabs (fgs. 3 and 4). During favorable seasons a dark-colored mold (*Cladosporium Citri*) develops dense stands of sporophores on many of these scabby surfaces and produces enormous quantities of dark spores. This fungus is usually considered the cause of sour scab, although it is often not present in scabby spots in early summer.

If persistent winds prevail during the early development of new growth, the tender expanding leaves are often slightly injured by rubbing against others. The portions thus affected may die and drop off, but they more commonly remain alive without continuing the normal growth, and thus

give rise to crippled and puckered leaves that are frequently mistaken for scabby ones. Fruits may also become misshapen or develop blemished rind owing to rubbing occasioned by wind.

CONDITIONS FAVORING THE DEVELOPMENT OF THE DISEASE

Sour scab may vary greatly in severity from year to year, and often from tree to tree. In some seasons its early stages indicate very heavy losses that subsequently fail to materialize; as the affected young fruits enlarge the conical warts may flatten out sufficiently to permit the marketing of the fruit.

The observations made during the past three seasons show beyond a doubt that even when located in the scabbiest groves, trees making only a slight early spring growth are never severely affected by the disease. Only an occasional leaf or fruit of such a tree may show traces of sour scab. Some of these trees develop a very strong first growth in some years and consequently may have a correspondingly severe attack of the disease.

Usually sour scab is most prevalent on grapefruit trees on soil furnishing abundant water throughout the year. It should be noted too, that such trees set fruit practically every season, if given proper care; and that they also grow faster and more per year than those on high-pine land. However, if the air is fairly dry and the weather mostly warm and bright during the development of the first spring flush, scab may fail to develop even in such moist and fertile localities, and in which most of the old leaves are scabby. On the other hand, the disease often becomes very severe in groves on high-pine land if the soil has been enriched by heavy applications of fertilizers high in nitrogen and the weather is cold and wet during the development of the first spring growth.

The stock on which grapefruit trees are budded also has a determining influence on the relative amount of sour scab that develops. The disease is more abundant on trees budded on rough-lemon stock than on those budded on sour-orange stock. However, this difference in the susceptibility of grapefruit buds may be simply due to the relative amount of early growth produced on the two stocks. It is a well known fact that, other things being equal, buds on rough-lemon stock outgrow those on sour-orange stock.

As the conditions just enumerated indicate, the fertilization and cultivation of a grapefruit grove is doubtless also of some significance in the development of sour scab, especially on the sandy, high-pine lands. As mentioned above, while most of the trees in a scabby grapefruit grove are putting forth a very strong early spring growth, a few trees scattered among the scabby ones, may grow but little in early spring and be free of

scab. These slow-starting trees may put on a heavy growth in late spring that nevertheless remains practically free of the disease. The weather in

FIG. 1. Sour scab may be fully developed on the first spring growth of grapefruit trees by the time the first blossoms open. This photograph shows one open blossom and three blossom buds.

late spring is usually warm and bright, and both soil and air are less moist than during the early part.

Some trees in scabby groves, under observation during the past two

years, have retained the late-starting habit and remained practically free from the disease; others of the same variety appear to be variable as regards this characteristic. In some cases depressing effects of one season appear to induce late-starting the following season. In this connection it is of interest to note the possibility of selecting strains from each of the important commercial varieties of grapefruit, that possess this late-starting habit to a marked degree and thus avoid some of the trouble with this disease. Such strains appear to occur in some bearing groves of

FIG. 2. June-bloom oranges, from sweet-seedling trees, showing the presence of scabby warts on the fruit, but no trace of disease on the leaves.

the variety Marsh Seedless, and it seems worth while making tests for the constancy of the late-starting habit.

It is only a few years since sour scab was more appropriately termed lemon scab. In those days the grapefruit was more rarely attacked and usually only mildly. Subsequently grapefruit trees were substituted for most of the lemons, and the growers put their best efforts and most of the fertilizer on the grapefruit while the remaining lemon trees were neglected. At present one sometimes finds the lemon trees having only traces of the disease while nearby grapefruit trees may be very scabby. Under certain

conditions the June-bloom oranges also become scabby, while the leaves are scabless, as shown in figure 2. June-bloom grapefruits often become

FIG. 3. June-bloom grapefruit, showing both flat scabby regions and scabby warts. No trace of the disease was present on what seemed to be the corresponding crop of leaves.

scabby also, while the foliage produced at the same time is free of scab (fig. 3). From a report received from Cuba last year, it appears that on

that island the leaves of grapefruit may be free of scab while the fruits are seriously affected. Such a condition is also shown in figure 4.

In nurseries the disease often becomes destructive among sour-orange and rough-lemon seedlings, and sometimes among the young grapefruit buds. Such seedlings and small nursery trees sometimes become stunted to a marked extent by this disease.

FIG. 4. Grapefruits of the crop of 1914, showing many flat scabby areas as well as warty protuberances. When these fruits were small they appeared more like those shown in figure 3.

THE FINANCIAL LOSS DUE TO SOUR SCAB

The annual loss from sour scab in Florida is heavy. In 1896, Swingle and Webber[1] estimated that the lemon industry sustained a loss "not far from $50,000." At the present time the loss in Florida alone sometimes is as much as a half million dollars a year on account of scabby grapefruit. In Cuba, Porto Rico, and the Isle of Pines the disease is often even more serious than in Florida. This is a heavy tax on the grapefruit business of the state, and one that can at least be partly avoided.

[1] Swingle, W. T. and Webber, H. J. The principal diseases of citrous fruits in Florida. U. S. Dept. Agr., Div. Veg. Phys. Path. Bul. 8: 21–25. 1896.

THE CAUSE OF SOUR SCAB

The conditions mentioned above as being commonly associated with the development of sour scab in grapefruit groves bring out many points of interest in regard to the cause of this trouble. When these data are considered in connection with the distribution of the disease in citrus sections, it appears that the moisture relations must be given prominence. It is evident that the development of the trouble is somehow dependent upon the presence of abundant moisture in the soil or air, or in both.

While the leaves of sour-orange, rough-lemon, and grapefruit are emerging from the bud, and during their period of rapid expansion, they usually become more or less thickly speckled at night with drops of moisture. When the leaves are larger both sides accumulate moisture. The amount of water thus accumulating apparently by both exudation and condensation, on expanding leaves seems to vary with the change in the humidity of the air. When the humidity is near the dew-point the small drops often become confluent and cover most of the surface of these leaves, and if the air continues moist the under sides of such leaves may remain moist several days at a time, while in periods of low air humidity the excessive moisture accumulated over night, evaporates early the next day. Until the leaves are fully grown water more readily covers them because they lack the waxy cover of fully developed leaves. During the early spring of 1915 the air was very moist and cold while the first growth was in its early stages and as a result sour scab developed in great abundance even on high sandy land if the growth was early and vigorous.

It is a well known fact that the acidity in growing plants is higher at night and during cloudy days, or when the weather is cold and wet than it is while the sun shines. Therefore the question may be raised: Do the excessive acidity induced by wet, cold weather and the resulting high osmotic pressure have a causal relation to the development of the disease? It is an interesting fact that the above mentioned water accumulating on expanding young leaves is neutral as far as can be determined by the litmus test.

When growing actively, the varieties of Citrus which are most subject to this disease emit a rather strong aroma suggestive of acid. Since the presence of a film of water on such developing growth seems to be a requisite for the development of sour scab, it seems probable that at night or during the time such aqueous films cover the expanding leaves, some of these exuded aromatic substances are absorbed by the water. In certain environmental conditions the oil-glands seem to become large and distended just as though the production of oil were exceeding their capacity. Under such conditions the amount of aromatic substances emitted is doubtless

more than it is under lower hydrostatic pressure. Consequently if this water film is retained during considerable periods at a time it may accumulate enough of these substances to cause mild injury and local stimulation of growth. Besides, experience with deciduous fruits indicates that the long-continued presence of liquid water on fruits may apparently by itself induce injuries like russetting of apple and pear. Citrus seems to be subject to such injuries only while the waxy cover is yet thin or wanting.

When the embryonic leaves of vigorously growing sour-orange or grapefruit trees begin expanding, the oil-glands, as mentioned above often protrude greatly above the outer surface of the emerging leaves. In some cases a few of these protruding oil-glands may break open, thus giving rise to crater-like conical elevations, the upper margins of which grow more or less and tend to close the pit. In cases in which the base of such a papillum grows very strongly the former oil-gland becomes elevated on a conical growth of superficial tissues and its tip becomes covered by flaky epidermal fragments arising in what was formerly the crater-like depression of the broken oil-gland. If the tissues surrounding the base of such a ruptured oil-gland fail to grow very strongly no elevation above the general surface results. Instead the rapid expansion of the surface of the affected leaf or fruit causes the place of rupture to cover a large area. This area arising by the expansive growth of the basal portion of the broken oil-gland, is largely or wholly covered by flaky, dead scales developed from subepidermal cells (fig. 2). As a matter of fact, these are only two of the simplest types of growth on citrus leaves, fruits, and twigs that are usually called scab. The growth forms are various, and intermixed to a great extent (compare figs. 2, 3, and 4). The surfaces of the warty growths are smooth where they are covered by normal epidermis, and rough where they are covered with an admixture of tiny dead scales and rough growth, regenerated in regions of primary injury (figs. 3 and 4). The irregularities are greatly increased by the subsequent rupture of other oil-glands as the leaf expands. It seems that the oil from the broken glands injures and often kills the epidermis around the openings. The writer has been unable to establish definitely what substance present in the young oil-glands induces the injury and the hypertrophy resulting in warts. The main constituents usually derived from orange oil such as limonene, anthranilic acid, and methyl anthranilate, when applied to leaves and the bark of young branches, even in slight quantities with an atomizer, cause serious injuries, yet these compounds are apparently neutral to litmus. When the oil-glands of orange and grapefruit are punctured with a very fine needle and the oil is allowed to overflow the rind of the immature fruit or the epidermis of the leaf, the outer layers are injured or even killed over practically the entire area touched by the oil. Unfortunately, the

work could not be completed so that much remains to be determined, especially regarding the development of scabby warts from injured oil-glands in the more acid varieties of Citrus. Some inferences are based on unsubstantial evidence, because of the necessity of closing the work. These observations and some ideas they suggest are recorded so that in future studies consideration may also be given them.

The above-mentioned cultural methods as well as the weather seems to have much influence on the development of excessively large oil-glands in the early stages of vernation, and it seems that excessive moisture later in the season or when the tissues are older, also leads to the development of dermal injuries which appear to arise about broken or distended oil-glands. The diseases known as melanose and ammoniation seem to develop in that way. The appearance of these maladies differs from scab, however, in that instead of warty outgrowths, small brown elevations and gummous patches arise that make the affected surface feel like very coarse sandpaper. The ammoniation of oranges may probably be induced in several ways, but one of the simplest methods consists in fertilizing the trees heavily with nitrate of soda in spring and again in late May; yet this method is successful only *in case heavy rains fall in mid- and late summer.* Attention was called to the more important of these facts in a former paper,[2] in connection with decay of the fruit.

It is an interesting fact that sour scab has always been attributed to the fungus, *Cladosporium Citri*, and that *some* of the inoculation experiments performed by Fawcett[3] upheld the assumption that this fungus is the cause of the disease, while others were either negative or neutral. The statements by Scribner[4] and later by Underwood,[5] to the effect that the disease is due to a species of Cladosporium, are insufficiently supported by evidence. The writer's observations on the development under field conditions of this disease in 1913 and 1914 made him doubt the correctness of this hypothesis; and the inoculation tests made in the spring and summer of 1915, with spore suspensions from both pure cultures and from numerous leaves having great quantities of viable spores of the fungus on their scabs, supported the doubt—not a single indication of the disease developed on the vigorously growing sour-orange seedlings used in the tests. The inoculations were repeated three times, during three differ-

[2] Experiments on the decay of Florida oranges. U. S. Dept. Agr., Bu. Pl. Ind. Cir. 124: 17–28. 1913.

[3] Fawcett, H. S. Citrus Scab. Fla. Agr. Exp. Sta. Bul. 109: 51–60. 1912.

[4] Scribner, F. L. Notes on the orange leaf scab. Bul. Torr. Bot. Club **13:** 181–183. 1886.

[5] Underwood, L. M. Diseases of the orange in Florida. Journ. Mycol. 7: 34. 1891.

ent growth periods. The same results were obtained on young budded grapefruit trees on sour stock.

In the spring of 1914 a number of sour-orange seedlings which were about two years old, were cut back to stubs about a meter high. Three of them were carefully scrubbed with a 1 to 1000 mercuric-bichloride solution and immediately inclosed in cheese cloth stretched around four stakes driven in the ground. The tops and bottoms were also closed with cheese cloth. Two unsterilized trees were inclosed with cheese cloth at the same time. Other trees were only partly inclosed.

After the completion of the spring growth (the last of April) the leaves were counted on all trees under experimentation. The percentage of scabby leaves on the inclosed trees was practically as great as that on those in the open, and the trees sterilized before enclosing were almost as scabby as the others, about 4 per cent of the leaves being affected.

The cultural tests made from numerous early-stage scabs of both fruit and leaves only rarely gave Cladosporium, and more frequently other fungi. In mid- and late summer the scabs having Cladosporium present could usually be selected with the unaided eye because the dark-fruiting fungus was readily seen. This fungus generally could not be obtained from the scabby warts where its spore masses were not evident at that time.

After considering the various possibilities that may be involved in the origin and development of sour scab, its cause becomes obscured rather than clarified, although interesting glimpses are seen of processes that may give some additional clues regarding its cause. The tangible evidence in support of the idea universally held, that *Cladosporium Citri* causes sour scab, is slight and inconclusive. In fact, the evidence to the contrary is even stronger. It all tends to show that the question needs more extended critical study before conclusions can be drawn regarding the cause of this disease.

The results of the spraying experiments to be detailed below, however, apparently give support to the theory that this disease is due to some pathogenic organism, although it is also possible that the sprays may have some other than germicidal action in the prevention of sour scab.

THE PREVENTION OF SOUR SCAB BY SPRAYING

During the past three seasons experiments in the prevention of the sour scab disease have been carried on in cooperation with growers in different sections of the state of Florida. The results show that preventive measures pay even under the most trying conditions.

In 1913 bordeaux mixture made according to the formula 3–3–50, and lime-sulphur solution, testing 32°B., diluted 1 to 40, were used on

separate rows. The number of applications for the season varied from three to six. The early stage of scab was noticeable on the new growth when the first application was made during the first week in March. In another grove the first application was made on April 20. In the grove first sprayed early in March both bordeaux and lime-sulphur prevented the development of much scab when compared with the unsprayed rows. But where the first spraying was done on April 20 the sprayed trees had practically as much scab as the checks.

In 1914 the first application of spray was made on February 26 in one case, and in another on March 6. Some scab was noticed on the new growth in both groves when this application was made. The result was much like that for 1913, in that the check rows had appreciably more scab than the sprayed ones. But all sprayed rows also had scab. Those sprayed with bordeaux mixture had somewhat less than those sprayed with lime-sulphur solution.

In 1915 the first application was made on February 25 to 27 in one grove, and on March 8 in another. Some scab was noticed on the earliest new growth in both groves. The second applications were made eight days after the first and later ones at intervals of eight to twenty-one days.

The results were surprising in that the new growth, developing during the frequent early sprayings, was practically as scabby on the sprayed as on the unsprayed trees, except on the few scattered trees which had made but slight growth. The fruit, however, showed marked differences between the sprayed and the unsprayed rows, as well as between those sprayed with bordeaux mixture and those receiving lime-sulphur solution, the former giving better results as far as scab is concerned.

In the case of a grove near Orlando where the disease had been uncommonly bad during at least three years, and where enough fruit occurs to permit a fair comparison, the results were as follows: On the rows sprayed with bordeaux mixture, 60 per cent of the fruit was scabless, and on the rows sprayed with lime-sulphur only about 32 per cent was free of scab, while on the unsprayed, or check rows from 95 to 100 per cent of the fruit was scabby.

In another grove under experiment near Bradentown in 1915, the results were even more definite and better, in spite of the fact that only a few scattered trees in each row bore fruit of any consequence: usually two to four trees per row bearing from two to six boxes each. In this case bordeaux mixture was used on one row, lime-sulphur solution on four rows and soluble sulphur on four rows. Three rows were left as checks, unsprayed.

The percentages of scabby and scabless fruit were obtained by counting and arranging in two classes, all fruit on five unsprayed trees out of sixty-

three, on two of the twenty-one on which bordeaux mixture was used, on four of the eighty-four trees sprayed with lime-sulphur solution and on four of the eighty-four trees sprayed with soluble sulphur compound. The unsprayed trees averaged only 17 per cent of scabless fruit, while those sprayed with bordeaux had an average of 93.5 per cent in that class. The trees sprayed with lime-sulphur solution and soluble sulphur compound gave practically the same results, both having over 50 per cent of scabless fruit.

For this season, then, the results were not only below those of the two previous seasons in the protection afforded the fruit, but the first spring growth seemed to have developed scab this season irrespective of spraying. Yet, in spite of the lesser degrees of protection afforded by the sprays this year, the difference between the sprayed and unsprayed trees was still great enough to make spraying a good investment even if lime-sulphur alone were used.

THE RESULTS AND CONCLUSIONS WARRANTED BY THESE SPRAYING EXPERIMENTS

In determining the practicability of spraying to protect the young fruit from scab, it is better to base the conclusions on results obtained under adverse conditions than on those from the more favorable seasons, because in that way the efficacy of a method will more likely be under- than over-estimated. This may be illustrated by citing the results secured in 1913 and 1914, as compared with those of 1915. Although scab was abundant during those two seasons, the preventive methods yielded a much higher percentage of scabless fruit than in 1915. A general summary of the two years shows about 75 per cent scab control for bordeaux mixture and about 60 per cent control for lime-sulphur solution for both foliage and fruit, while the check or unsprayed rows showed scab on about 60 per cent of both fruit and leaves. This comparison shows beyond a doubt that general conclusions are not admissible from less than three years tests, and that even three years is a short time for anything but tentative conclusions. The inferences to be drawn from results secured in 1915 are that sometimes it may be impractical to prevent sour scab from appearing on foliage, either with bordeaux mixture or with lime-sulphur solution; while for the fruit the bordeaux gave even a higher percentage of protection than in former seasons, and lime-sulphur fell lower in its efficiency by about 18 per cent, than it had during the two preceding years. For the fruit the average for the three years shows bordeaux to give 79 per cent, and lime-sulphur 45 per cent protection from scab.

The experiments of 1915 show that even under severe conditions it is

needless to spray more than four times and that for the protection of the fruit alone three applications suffice. A portion of the grove near Orlando was sprayed nine times, while in that near Bradentown the rows sprayed only four times were as well protected as those sprayed six times. The same thing is also shown in comparing the results on rows 18 to 22 of the grove near Orlando which were sprayed only six times, for they have as much scabless fruit as the rows sprayed eight or nine times.

These results also show that ordinarily it is a waste of time and material to spray after the middle of May for scab. In the grove near Bradentown where only four applications were given to some rows, the last spraying was done on April 16. The omission of the late-May application from certain rows in the grove near Orlando, did not reduce the percentage of scabless fruits for those rows.

A TENTATIVE SPRAYING SCHEDULE FOR SCAB

If it is desired to prevent scab on the new growth or foliage, the first application should probably be made a little while before growth starts in spring and should cover all the old foliage. If only the fruit is to be protected from scab the first application of spray should be made when the bloom has reached its height or just after the earliest blossoms drop, and should be given chiefly to the new growth. This treatment also serves as the second application for the protection of the new growth. The second application for the fruit should be made about a week or ten days after the first, and be confined mainly to the new growth and fruit. The third and last spraying for the fruit or the fourth for the new growth should be made in about two to three weeks after the second fruit application.

Both lime-sulphur solution and bordeaux mixture have certain defects, when used separately for the prevention of scab, that it would be desirable to eliminate if possible. Bordeaux sticks rather too tenaciously to be used more than once or twice in a season; and the application made during the height of the bloom sometimes kills back some of the youngest growth. If the mixture is applied during the emergence of the new growth, nearly all of it may be killed back.

Even though great care is taken to always hold the spray nozzles directed downward and chief attention is given to the new growth and fruit, an appreciable increase of scale insects usually follows the *repeated* use of bordeaux mixture, though it is generally not necessary to spray for scale until two to five months after the last treatment with bordeaux mixture. A much higher percentage of the bordeaux-sprayed fruit may become russet. In fact, in 1915 only the trees sprayed with bordeaux mixture bore russet fruit.

Lime-sulphur solution, testing 32°B., diluted 1 to 40, as used in the above experiments, gives a lower degree of protection from scab; however, it does not injure the tenderest growth, and at the same time kills rust mites in all stages, as well as the creeping forms of scale insects.

From the results cited here as well as from others not mentioned, the writer suggests the use of lime-sulphur testing 32°B. (or its equivalent) made up 1 to 30, just before growth starts in spring, if it is desired to protect the earliest new growth. Bordeaux mixture made up according to the formula 3–3–50, is to be applied during the height or middle of the blooming period, and either bordeaux or lime-sulphur solution, 1 to 40, should be used a week or ten days later. A final spraying, of lime-sulphur solution (1 to 40), should be made in two to three weeks.

This schedule obviates the most undesirable features encountered when using either bordeaux or lime-sulphur alone, and at the same time will give a high degree of protection from sour scab, and also keep down the mites and scales to a minimum.

THE COST AND RETURNS FROM SPRAYING

Using the results from the tests of 1915, it is readily seen that the net returns from spraying for sour scab depends not only upon the efficiency of the spraying and the material used, but also upon the amount of fruit the trees bear. Neither of the groves used for experimentation had a full crop; in fact one of them had fruit of consequence only on scattered trees. Thus the net profit becomes much reduced. In the best portion of the other grove the trees had about a half crop, or four boxes per tree. Here the net returns from spraying are more worth while even for a season in which prevention was difficult.

In order to get figures that will apply to an ordinary crop-year in a grapefruit grove, it is best to use only the counted sprayed and unsprayed trees in the two experiments as a basis for general deductions.

For a generalized view that aids in drawing conclusions regarding the cost and net returns involved in spraying for scab, the following condensed table is useful.

It will be seen from table I that on the twenty-four sprayed trees, from which counts were made, 51 per cent of the fruit was scabby while on the eight unsprayed trees counted, 95 per cent of the fruit was scabby. On the basis of trees set 25 by 25 feet and yielding four boxes of fruit per tree and assuming that scabless fruit sold at $1 per box and scabby fruit at $.50 per box, there would be secured from an orchard, as severely affected as those used in the experiments, a gross income of $205.50 per acre.

On the same basis an unsprayed grove would yield only $144.90. After deducting $17.60 per acre for spraying there would be left a net profit for spraying of $43 per acre. This additional profit per acre would often make the difference between profit and loss and would therefore be a great stabilizer for the citrus business. Figured on the basis of an investment to the amount of the cost of spraying, it shows the handsome profit of 244 per cent. The conclusion is therefore obvious that it pays to spray for scab.

TABLE I

Generalized summary of spraying experiments for control of citrus scab

Orlando experiment

MATERIAL USED	NUMBER OF TREES COUNTED	TOTAL NUMBER OF FRUITS	SCABLESS FRUITS		SCABBY FRUIT	
			Number	Percentage	Number	Percentage
Bordeaux	5	1281	887	69⅓	394	30⅔
Check	4	1262	6	½	1256	99½
Lime-sulphur	9	2371	542	22⅘	1829	77⅕
Bradentown experiment						
Bordeaux	2	628	587	93½	41	6½
Check	4	597	88	14½	509	85½
Lime-sulphur	4	1024	527	51½	497	48½
Soluble sulphur	4	843	454	53½	389	46½

THE CONTROL OF SCAB BY PRUNING

No first-hand or independent experiments have been conducted in an endeavor to protect the new growth from scab by pruning out the old growth that is scabby, but a number of such experiments by growers in different parts of the state have been closely followed during the past three seasons. Some of these experiments have been on a large scale and have been executed with care and therefore give some notion of the feasibility of the method when applied in localities where the disease is prevalent. But of course the results do not apply to sections where scab occurs only mildly, and on scattered trees.

Without going into details it may be said that the results do not warrant making it a general method of combating the disease in bearing groves, in places where it usually occurs in abundance. As a matter of fact no improvement is usually noted from such pruning except when the disease occurs only on a few isolated or scattered trees. In several instances of wholesale pruning of badly scabbed bearing groves, the results have not only been of questionable value, but the subsequent new growth seemed to develop as much scab as that on the unpruned trees.

SUMMARY

1. Sour scab of citrus causes a great financial loss in the growing of grapefruit in Florida, Cuba and the Isle of Pines.

2. The disease develops most destructively in seasons and localities having abundant moisture in both air and soil during the development of the first spring growth (may not apply to the June bloom).

3. Trees starting growth latest in spring are least subject to sour scab; therefore, the selection of buds from such individual trees chosen from among the best commercial varieties of grapefruit, may also prove of value in reducing the loss from this trouble.

4. Grapefruit trees budded on rough-lemon stock, are more susceptible than those on sour-orange stock.

5. The causes of the disease have not yet been satisfactorily determined. *Cladosporum Citri*, to which the disease is usually attributed, is at most, only partially responsible.

6. The long-continued presence of liquid water on rapidly growing leaves and shoots, and on very young grapefruits, in connection with excessive hydrostatic pressures often developing incident to strong growth, and probably the accumulation of injurious volatile products in water films on such growing leaves and fruits, appear to have a causal relation to the development of sour scab.

7. Experiments carried on during three years in cooperation with growers have shown that it is both practical and highly remunerative to spray grapefruit trees in susceptible localities three or four times with bordeaux mixture and lime-sulphur solution. One application of bordeaux mixture during the height of the blooming period, followed in a week or ten days by one of lime-sulphur solution, and by a second one of lime-sulphur solution in from two to three weeks after the second spraying, is suggested as the best schedule for the protection of the fruit.

8. The method of pruning out of scabby growth from severely affected groves is impractical and sometimes even injurious to the trees.

APOPKA, FLORIDA

CUCUMBER MOSAIC DISEASE

W. W. GILBERT

WITH PLATE V

A new mosaic disease of the cucumber, commonly called white pickle, has made its appearance during the past few years in greenhouse and field in various sections of the country where cucumbers are grown commercially.

Occasional specimens of this trouble have been received by the U. S. Department of Agriculture from different greenhouses during the past seven or eight years. Selby reported the occurrence of a mosaic disease of cucumbers in the Ashtabula, Ohio, greenhouses as early as 1902 and Stone reported a similar disease in Massachusetts greenhouses in 1909. Both state that there was no evidence of contagion so that it is probable that another type of mosaic possibly due to malnutrition, was referred to. At the present time the mosaic disease is known to occur in greenhouses in Minnesota, Michigan, New York, Pennsylvania, Illinois, Indiana, Ohio and Louisiana.

The occurrence of the disease in field-grown cucumbers seems not to have been reported and has not been generally known until within the last two years. Recent conversations with pickle growers of the Middle West and with others make it appear reasonably certain that the trouble has been present in the field for at least ten years. It is now known to occur in the field rather generally in Wisconsin, Michigan, and Indiana, and has been found also in Ohio, Iowa, Illinois, Vermont, New York, Minnesota, Massachusetts, and Virginia, and in Ontario, Canada.

In 1914 Mr. S. P. Doolittle, of the Michigan Agricultural Experiment Station, and Mr. I. C. Jagger, of Cornell University, began work on this disease independently. Mr. Jagger has studied the trouble as it occurs in the greenhouses of Irondequoit, New York, and vicinity, and all his experiments have been carried on in the greenhouse. Mr. Doolittle's work has been with cucumbers grown in the field for pickling purposes. In 1914 he was located at Hamilton, Michigan, where the disease had been serious the previous season. In 1915 the U. S. Department of Agriculture inaugurated a cucumber disease project in cooperation with the Michigan Experiment Station and others, in charge of the writer and subsequent work by Mr. Doolittle on cucumber mosaic disease has been done

under the joint direction of Dr. E. A. Bessey of the Michigan Agricultural Experiment Station and the writer. The past season some work was continued at Hamilton but the major part of the experiments was performed at Big Rapids, Michigan, where a cucumber disease laboratory was located.

The results secured by Mr. Doolittle and Mr. Jagger were found to agree in so many particulars that it was thought advisable to publish thus simultaneously this preliminary statement of progress to date.

BUREAU OF PLANT INDUSTRY
WASHINGTON, D. C.

EXPLANATION OF PLATE V

FIG. 1. Cucumber plant in a field at Holland, Michigan, badly affected with mosaic disease. Lead pencil shows relative size of plant. At (*a*) note runners very much dwarfed with very small wrinkled leaves, at (*b*) a very warty fruit. Photograph made August 19, 1915. W. W. G.

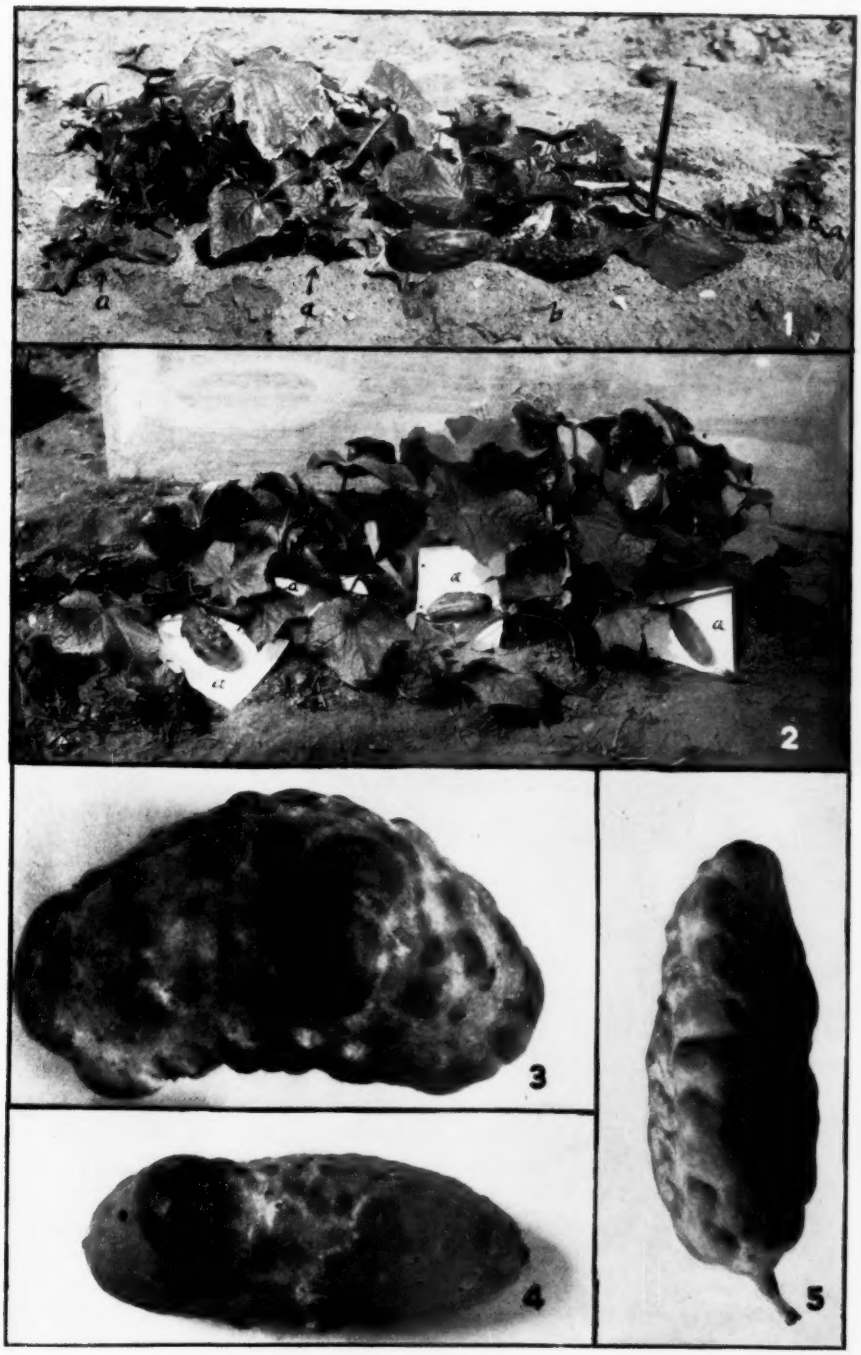
FIG. 2. Cucumber mosaic disease produced at Big Rapids, Michigan, by S. P. Doolittle, by transferring to a healthy plant aphids from a mosaic diseased plant. Note at (*a*) the warty and mottled fruits, the principal symptoms showing when this photograph was taken. Photograph made September 1, 1912. W. W. G.

FIGS. 3 and 4. Fruits from cucumber plants at Holland, Michigan, affected with mosaic disease.

FIG. 3. Misshapen fruit with large and small warts of dark green color, remainder of pickle mottled light and dark green.

FIG. 4. Small pickle, yellowish white except for the large dark green wart at one end and a few scattered spots of green. Photograph made August 22, 1915. Crandall.

FIG. 5. Small mottled and warty pickle from mosaic diseased vine in the field at Irondequoit, N. Y. Photograph made by I. C. Jagger.



CUCUMBER MOSAIC

A NEW INFECTIOUS MOSAIC DISEASE OF CUCUMBER

S. P. Doolittle

The cucumber mosaic disease shows most markedly on the fruits, the first sign being a yellowish mottling near the stem end. In advanced stages these light areas are found on all parts of the fruit, the darker portions frequently being raised so as to form protuberances. In later stages, the fruits may be pale and smooth, either with or without mottlings of darker green. Some fruits throughout the season are merely a darker green than normal and show the disease chiefly by their striking distortions. At the period of greatest intensity of the disease the stems and petioles are dwarfed, the leaves become a mottled light and dark green, often with the "savoyed" or wrinkled appearance characteristic of mosaic diseases. The disease often begins with a yellowing of some portion of the leaf. Ordinarily this is restricted to a V-shaped area between larger leaf veins. Following this early symptom, the disease appears throughout the plant, occurring on all the older leaves of a runner. Such affected leaves may die early and are then replaced by dwarfed shoots, usually bearing mottled leaves. These grow slowly, blossom but sparingly and set only occasional fruits, which, however, may become of medium size at maturity. What is probably the same disease has also been observed on pumpkin, squash, muskmelon, and wild cucumber (*Echinocystis lobata*). In the case of the muskmelon, a mosaic disease was found causing a total loss in fields at Jackson and Grand Rapids, Michigan.

The writer devoted much time in the summer of 1914 to field observations at Hamilton, Michigan, no work, to the writer's knowledge, having been done on the disease in the field up to that time. No constantly associated organism could be found but the rapid spread of the disease through fields in the vicinity indicated that it was highly infectious. Aphid injury was extensive in all these fields.

Inoculations made August 22, 1914, by injecting healthy vines hypodermically with the juice extracted from mosaic-diseased plants gave eleven diseased plants out of seventeen inoculated, the disease appearing in from eighteen to twenty days and all check plants remaining healthy. This work was done in a field apparently free from the disease, although a small amount of disease appeared in distant parts of the field before the close of the experiments but none, however, in portions used for the inoculation experiments.

Some work was done in the laboratory and greenhouse of the Botanical Department of the Michigan Agricultural College during the winter of 1914–1915, but it was hampered by limited space and severe thrips and nematode injury. Results obtained, however, pointed to the correctness of the conclusions of the previous summer.

During the summer of 1915, field experiments were conducted in cooperation with the Bureau of Plant Industry at Big Rapids, Michigan, a district comparatively free from mosaic in recent years and on land which had never grown cucumbers. All vines used for inoculation work were enclosed within cages covered with unbleached bunting which excluded insects and yet allowed normal growth. One spontaneous case of mosaic appeared in the field about July 24, but this vine was caged at once to prevent possible spread by insects and no further cases appeared in the field during the summer.

Successful inoculations were obtained in fifteen out of nineteen cases by tearing off leaves from healthy vines and touching the wound with the broken end of a petiole from a diseased plant. Well marked symptoms of the disease appeared in eighteen days.

The fresh expressed juice of diseased plants as well as that from diseased fruits, when injected into healthy vines, produced the disease in twenty-four out of thirty-eight cases.

An extract of diseased plants, passed through a Berkefeld filter produced infection in three out of five cases.

Pieces of diseased vines when inserted into the stems of healthy plants gave a typical mosaic in four out of six cases.

One cross-inoculation from a mosaic-diseased pumpkin vine to a healthy cucumber plant was also successful.

The rôle of insects in transmission of the mosaic disease was proved by transferring a few melon aphids (*Aphis gossypii* Glover) from mosaic diseased vines to healthy ones, under cages as above, infection resulting in thirty-seven out of thirty-seven cases, the first symptoms appearing after fourteen days. In one successful experiment, only three aphids were used. Aphids transferred from healthy vines to healthy vines, however, failed to produce any mosaic symptoms, hence this disease is not of the type known as stigmonose.

A plot of ground at Hamilton, Michigan, where the crop had been a total loss for the past three years, due to the mosaic disease, was planted to cucumbers in 1915. Thirty vines were caged when the first leaf appeared and others were similarly caged at intervals of two to three weeks. At the end of the season *all* uncaged vines showed the mosaic disease and 50 per cent of the vines which had been caged *after* the disease first appeared in the field, though at that time apparently healthy, were

affected. On the contrary, all the thirty vines covered early and thus kept free from insects from the beginning remained healthy. This experiment seems to exclude soil and possibly old vines and trash as the primary source of infection, and gives further evidence of the insect transmission of the disease.

Experiments as to the methods of over-wintering, distribution by other insects, introduction into new localities and control are now under way and a full report will be published when the work is completed.

During the fall of 1915, work was continued in the greenhouse of the Botanical Department of the Michigan Agricultural College.

Successful cross-inoculations were obtained on muskmelon by the use of aphids from a mosaic cucumber plant. Re-inoculation to the cucumber was not successful, but only old vines were available and these do not show the disease readily.

The incubation period which was twelve to fourteen days in the field was reduced to six to seven days in the greenhouse.

A type of infection also appeared which the writer had not observed in the field, the entire vine wilting rapidly in a manner similar to those affected with the bacterial wilt.

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EXPERIMENTS WITH THE CUCUMBER MOSAIC DISEASE

I. C. Jagger

The writer's experiments carried out in the vicinity of Rochester, N Y., have been confined to the mosaic disease as it occurs in greenhouses. Undoubtedly the greenhouse disease is identical with the field disease, although its development differs slightly. The early symptoms consist of a yellowing, mottling and warting of the fruits and a yellowing of the foliage with only slight mottling, thus agreeing with the field symptoms. One to several days after the first symptoms appear, the whole plant usually wilts and this is followed by the death and drying of leaves and growing tips. Sometimes the whole plant dies but usually the larger stems remain alive and after a few days send out new shoots. Wilting and dying apparently occurs only occasionally in the field, and this may be accounted for by harder tissues in the more exposed field plants. The new shoots present the same symptoms as in the field, being dwarfed and bearing decidedly mottled leaves and very warty fruits.

June 3, 1915. Leaves, stems, and fruits of mosaic diseased greenhouse cucumbers were crushed, the juice pressed out, filtered through filter paper and injected with a hypodermic syringe into the stems of two healthy bearing plants, about one cubic centimeter into one plant and a few drops into the second. One cubic centimeter of distilled water was injected into the stems of a third plant as a check. In six days one plant showed mosaic symptoms; in nine days the whole plant was wilted; the death of leaves and growing tips followed; in one month two dwarfed new shoots of four or five leaves each had appeared. At the end of two months the second inoculated plant and the check plant were still healthy. The mosaic disease had never before appeared in the range of greenhouses where these inoculations were made.

June 19. Juice from mosaic diseased plants was injected into seven healthy bearing plants, three receiving about one cubic centimeter each and four a few drops. One cubic centimeter of distilled water was injected into each of three similar plants as checks. In seven days one plant showed the first symptoms of mosaic and in twenty-three days six of the seven inoculated plants were diseased. The three check plants were healthy at the end of one month.

July 27. Juice from diseased plants, sterilized by passing through a Berkefeld filter was injected into three plants; unfiltered juice was in-

jected into three plants; distilled water was injected into three plants. In nine days one plant receiving sterile juice developed mosaic but all others were healthy at the end of five weeks. When inoculated the plants were fourteen weeks old and the stems had become so woody that the liquid was with difficulty forced into them. This may account for the poor results.

August 31. Three to twenty aphids (*Aphis gossypii* Glover) were transferred with a camel's hair brush from mosaic diseased plants to the following eleven healthy plants: eight small potted plants with two or three leaves each; one bearing plant six weeks old; one plant three months old, and one plant five months old. These plants were enclosed in cheesecloth cages. In four days a few plants showed mosaic symptoms and in seven days all were diseased except one of the potted plants, while two nearby bearing plants, receiving no aphids were healthy and of eight nearby potted plants receiving no aphids only one was diseased and this was probably due to the escape of an aphid.

October 1. A few aphids were transferred from mosaic diseased plants to seven small plants in pots and covered with a screen. In two weeks five plants were affected with mosaic while seven nearby plants receiving no aphids were all healthy.

October 9. Fifteen to one hundred aphids from healthy plants were transferred to each of seven small potted plants, and six to fifteen aphids from mosaic plants to seven similar plants. The two lots were covered with separate cages. In eleven days five plants receiving aphids from diseased plants showed mosaic while all receiving aphids from healthy plants were free from disease.

November 12. Yellow leaves of a plant that had recently developed mosaic disease were crushed in the hands. Eleven small potted plants, 3 to 12 inches high, and three large bearing plants were inoculated by rubbing a small area of both the upper and lower surface of two or three leaves on each plant with the crushed diseased leaves. Rubbing was sufficiently vigorous to break the epidermis and leave small pieces of diseased tissue clinging to the leaves. The leaves of a second lot of fourteen similar plants were inoculated in the same manner with dwarfed, much mottled leaves from a plant affected with mosaic for several weeks. The leaves of a third lot of fourteen similar plants were rubbed with clean hands as checks. At the end of fourteen days three bearing plants and two potted plants of lot one showed the first symptoms of mosaic, two potted plants of lot two showed questionable early symptoms of mosaic, and the fourteen plants of lot three were all healthy. At the end of nineteen days, three bearing plants and four potted plants of lot one showed mosaic, one bearing plant and three potted plants of lot two showed mo-

saic, and the fourteen plants of lot three were all healthy. Several plants in lots one and two, not included among those reported as diseased, showed questionable early symptoms of mosaic.

September 12. Six cucumber plants, growing in a greenhouse soil bench, in which all plants were healthy, were trained so that the foliage was in contact with the foliage of mosaic diseased plants in the opposite bench. The foliage was handled very little and with great care. In six to twenty-seven days four plants developed mosaic, while the other two were still healthy when removed at the end of two months. Eight similar plants alternately located and not in contact with diseased plants were healthy at the end of two months.

Eight plants were at the same time transplanted into the same bench with the mosaic diseased plants at distances of 5 to 10 inches from them, so that roots of healthy and diseased plants undoubtedly soon became interlaced. The foliage was trained so that it never came in contact with foliage of diseased plants. At the end of three months all eight plants were healthy.

December 1. Five small potted cucumber plants and two large bearing plants were inoculated by pinching. Three or four leaves on each plant were given a single pinch with thumb and finger, which had, immediately preceding each pinch, given a single pinch to a mosaic diseased cucumber leaf. Considerable pressure was applied in pinching, but care was taken to give no rubbing motion, which would tend to break the epidermis of the plants. No apparent juice or tissue was transferred but undoubtedly there was a transfer of many plant hairs. At the end of twenty-three days five potted plants and one large plant showed mosaic, while one large plant was healthy. Seven comparable check plants were all healthy.

December 1. Two plants of crookneck summer squash, two of garden or pie pumpkin, three plants of two varieties of gourd, and three plants of cucumber were inoculated by rubbing the leaves with crushed leaves of mosaic diseased cucumbers, as in preceding experiments. Ten exactly comparable plants were similarly rubbed with leaves of healthy cucumber plants as checks. All plants were small, and bore three to seven leaves. At the end of fourteen days all inoculated plants showed early symptoms of mosaic. At the end of thirty-four days all check plants were healthy; the three inoculated cucumbers had developed mosaic foliage, wilted and died; the two crookneck squashes had developed several dwarfed, mottled leaves with much shortened internodes, and one plant bore a fruit 2 inches long which was mottled and abnormally warted; the three gourds and two pie pumpkins had all developed dwarfed, mottled leaves with shortened internodes. Mosaic diseased gourds, pumpkins and squashes had showed no wilting and death of foliage and grow-

ing tips, such as usually occurs in cucumbers under such greenhouse conditions.

A mosaic disease, which appears to be identical with the one obtained by inoculation, has been observed during two seasons to be of common occurrence in fields of crookneck summer squash at Irondequoit, N. Y.

December 18. Potted cucumber plants, bearing three to seven leaves each, were inoculated by rubbing leaves with crushed leaves of mosaic diseased squashes and gourds, infected in the preceding experiment. Three plants were inoculated by using leaves from crookneck summer squash, three, by using leaves from one variety of gourd, and three by using leaves from the second variety of gourd. Two plants were rubbed with crushed leaves from each of three respectively healthy plants as checks. At the end of 16 days mosaic symptoms were evident. At the end of 28 days the six check plants were healthy; two plants inoculated from crookneck squash, two plants inoculated from one variety of gourd, and three plants inoculated from the second variety of gourd had developed mosaic foliage, wilted and died.

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FURTHER STUDIES IN THE RÔLE OF INSECTS IN THE DISSEMINATION OF FIRE BLIGHT BACTERIA

V. B. Stewart and M. D. Leonard

During the summer of 1914 experiments were conducted by the writers to determine the rôle of sucking insects in the dissemination of fire blight bacteria. In the experiments only insects were used which puncture the tissues of the plants with the bristles of their beaks. In discussing the results of the experiments which are recorded in a previous paper[1] the writers make the following statement: "Certain species of flies are attracted in considerable numbers to the gummy exudations of blighted trees and they, no doubt, carry the bacteria from place to place. It is possible that these flies may produce fire blight inoculations by injuring the tissue with their claws. However, no experimental data are at hand to substantiate this point."

During the summer of 1915 experiments were conducted with two species of flies which were abundant on apple and pear nursery stock in order to determine their ability to produce blight infections. Other experiments were performed also to determine the importance of several sucking insects as fire blight disseminators.

The experiments included the following species: *Pollenia rudis* Fabricius, *Empoasca mali* Le Baron, *Psylla pyricola* Förster, *Plagiognathus politus* Uhler and *Sapromyza bispina* Loew.

Young apple and pear seedlings with succulent shoots were selected and in caging the insects over the trees two types of cages were used. Where several seedlings were included in the experiment, the trees were covered with large cages in the shape of a triangular prism with the dimensions 3 by $1\frac{1}{2}$ by $1\frac{1}{2}$ feet. The cages were made of wire cloth twelve meshes to the inch and covered with cheesecloth. In some cases single trees were covered with small cylindrical cages about 15 inches in height and 4 inches in diameter, made of wire cloth and covered with cheesecloth. In each case the insects were transferred to the cages which were then inverted over the trees, care being taken not to injure the shoots during the operation.

[1] Stewart, V. B. and Leonard, M. D. The rôle of sucking insects in the dissemination of fire blight bacteria. Phytopath. **5**: 117–123. 1915.

A four-days-old agar culture of *Bacillus amylovorus* (Burr.) Trev. was used in all the experiments, the culture being smeared on the shoots with a camel's hair brush.

EXPERIMENT 1

Pollenia rudis Fabricius. This is the common cluster fly which is frequently found in houses especially in the spring and autumn. This species was found very commonly during the summer of 1915 on apple, pear, quince and peach nursery stock.

The experiment was set up July 12 and final results recorded August 5. A large cage was placed over six succulent apple seedlings two of which had been smeared with the agar culture of *Bacillus amylovorus*. About thirty cluster flies were released inside the cage. On July 27 the shoots of one of the trees which had been smeared with the culture were blighted. On August 5 the blight was slightly more advanced in the infected seedling but none of the other trees in the cage had become diseased.

In a similar cage about twenty-four cluster flies were released. No culture was smeared on the shoots. On August 5 no blight had appeared in this cage.

It is believed that the infections which occurred on the one tree smeared with the culture, were due to the presence of aphids on the shoots. When the cage was removed a careful examination showed the presence of several aphids on the seedling which apparently were overlooked at the time the experiment was set up. No aphids were found on the other trees and the fact that this was the only tree which blighted, seems to indicate that the aphids rather than the flies, were responsible for the infections. The results of experiment 2 substantiate this opinion.

EXPERIMENT 2

Pollenia rudis Fabricius. On July 27 eleven flies were allowed to walk over an agar culture of *Bacillus amylovorus* and were then placed in a large cage covering six seedling apple trees. Six flies which had not walked over the culture of the blight organism also were released inside the cage. The tips of two of the trees were smeared with a culture of the blight organism. On August 17 none of the trees had blighted.

A small cage containing ten flies was placed over an apple seedling. No culture was smeared on the shoots. The tips of two other seedlings were smeared with the blight culture and each tree covered with a small cage. The flies were excluded. On August 17 none of the shoots had blighted.

EXPERIMENT 3

Empoasca mali Le Baron. The experiment was set up July 12 and final results taken July 27. A cage was placed over six apple seedlings. The shoots of three of the seedlings were smeared with the agar culture of *Bacillus amylovorus*. About twenty-four apple leaf-hoppers were released within the cage. On July 27 two of the trees which had been smeared with the culture were badly blighted. No infections appeared on the other four trees.

A small cage containing eight leaf-hoppers was placed over an apple seedling. No culture was smeared on the shoots. On July 27 the check tree showed no blight.

EXPERIMENT 4

Empoasca mali Le Baron. On July 27 thirty adult leaf-hoppers were released within a cage which covered five seedlings, two of which were smeared with the agar culture of *Bacillus amylovorus*. On August 17, two of the shoots of one tree on which the culture had been placed, and two shoots of a tree not smeared with the culture were badly blighted. On another tree which had not been smeared with the culture there were fire blight lesions on the mid-rib of two leaves but the infections did not extend down the petiole to the twig. Many of the leaves were considerably curled by the feeding of the leaf-hoppers.

Six seedlings confined under a large cage were smeared with the culture of *Bacillus amylovorus* but the leaf-hoppers were excluded. On August 17 one shoot showed a slight infection of fire blight and on careful examination two leaf-hoppers were found on the leaves. Since it was impossible for the leaf-hoppers to have entered through the cheesecloth, apparently a too hasty search failed to reveal their presence before the cage was placed over the trees. A few of the trees in the experimental block were found previously to be infested with apple leaf-hoppers and this necessitated their removal before each of the experiments was set up.

Seven leaf-hoppers were placed in a small cage which was inverted over a single apple seedling. The culture was excluded. On August 17 nothing but leaf-hopper injury was apparent on the seedling.

EXPERIMENT 5

Psylla pyricola Förster. This is the common pear psylla. The adults and nymphs have been found commonly throughout the summer months on pear nursery stock in the vicinity of Rochester, New York.

On July 27 the terminal shoots of one of six pear seedlings were smeared with the agar culture of *Bacillus amylovorus*. Fifteen adult psyllas were

caged over these seedlings by means of a large cage. Ten adult psyllas which were first allowed to walk over a blight culture were also released under the cage. When examined for the last time, August 17, all the trees were free from blight.

On July 27 a pear seedling was covered with a small cage containing twelve psyllas. No culture was placed on the shoots. None of the shoots blighted.

On July 27 the terminal shoots of three pear seedlings were smeared with the agar culture of *Bacillus amylovorus* and a small cage placed over each tree. The psyllas were excluded. When final observations were made on August 17 none of the seedlings was diseased.

EXPERIMENT 6

Psylla pyricola Förster. On August 5, fifty adult psyllas were confined in a cage which was placed over six pear seedlings. The tender shoots of two of the seedlings had been previously smeared with the agar culture of *Bacillus amylovorus*. When examined for the last time three weeks later none of the shoots had blighted.

The shoots of five pear seedlings were smeared with the agar culture and covered with a large cage. The psyllas were excluded. All of the trees remained healthy. On August 5 twelve adult psyllas were confined within a small cage over one pear seedling but the blight culture was excluded. When examined August 25, no infections were apparent.

From observations made in badly blighted pear orchards where the psyllas were abundant, it seemed highly probable that these insects were responsible for many twig blight infections. The negative results of these experiments may possibly be due to the relatively few insects used in each cage, as compared to conditions in an orchard badly infested by psyllas. On the other hand, the shoots of the trees were tender and succulent and conditions were ideal for infections to occur, had any of the blight bacteria been deposited in the feeding punctures made by the psyllas.

EXPERIMENT 7

Plagiognathus politus Uhler. On July 21, thirty-five adults of this Capsid were allowed to walk over the agar culture of *Bacillus amylovorus* and then released under a large cage covering six apple seedlings. When final observations were made on August 5, five of the six seedlings were badly blighted and the other seedling showed a single infection.

On July 21, the shoots of three apple seedlings were smeared with the agar culture and each covered with a small cage. The bugs were excluded.

The trees remained healthy. At the same time eight adult bugs were liberated within a small cage covering an apple seedling but the culture was excluded. No infections occurred.

EXPERIMENT 8

Sapromyza bispina Loew. On July 21 a large cage containing twelve flies was placed over six apple seedlings. The shoots of two seedlings had been smeared with the agar culture of *Bacillus amylovorus*. When final observations were made August 5, none of the trees had blighted.

A small cage containing ten flies was placed over one apple seedling; the culture was excluded. No infections occurred.

Three apple seedlings were smeared with the agar culture, and each tree covered with a small cage but the flies were excluded. All of the trees remained healthy.

The results of experiments previously reported[2] in conjunction with those herein recorded include data on practically all the insects which might be important in producing fire blight infections in the nurseries of New York State. The false tarnished plant bug (*Lygus invitus* Say) and the apple red bugs (*Heterocordylus malinus* Reuter) and (*Lygidea mendax* Reuter) are occasionally found on nursery stock but they are undoubtedly of more importance in spreading fruit blight in orchard trees. Owing to the scarcity of these species in the nursery they were not included in the experimental work.

As seen from the results of experiments 1, 2 and 8, apparently the various species of flies are not active agents in increasing the number of twig blight infections. Although they feed in great numbers on the blight exudations and may carry the organism to other shoots, the method of feeding of the flies renders it improbable that the blight bacteria may become established in the tissues of the shoot. Repeated experiments have shown that the bacteria gain entrance to the tissue of the twigs only through injuries. It is not believed that such insects as flies are capable of producing wounds which afford an entrance of the blight organism into the twigs.

The injuries produced by certain sucking insects, such as the tarnished plant-bug (*Lygus pratensis* Linn.), often exude slightly and the possibility has been suggested that the blight ooze is carried to these insect punctures by flies which feed on the exudations from the wounds. Some of the blight bacteria on the fly's body being left in the exudation, later produce an infection by gaining an entrance to the tissue through the insect puncture. Infections might occur in this manner but the importance of the

[2] Ibid.

method may be over-estimated. Several factors are involved: hot, sunshiny weather rapidly dries out the exudation of the insect puncture, making it less attractive to the flies. Also the same conditions of weather affect the blight ooze laden with bacteria which is carried by the flies. The gummy substance soon becomes dry and hard thus reducing the chances of many bacteria being liberated in the exudation of the insect puncture. Also the longevity of the blight organism is relatively short when exposed to the direct rays of the sun. On the other hand, when the blight is very prevalent and there are also numerous flies and sucking insects present, a few infections may occur in the manner suggested above. It is believed that the flies are most important in carrying the causal organism to blossoms and occasionally to wounds as in such cases as have been previously reported by Stewart[3] where many injuries to the trees were produced by hail stones and the flies carried the blight bacteria to these wounds.

In a recent article by A. C. Burrill[4] are recorded the results of experiments conducted to determine the importance of the grain aphis (*Siphocoryne avenæ*) and the apple leaf-hopper (*Empoasca mali*) in the dissemination of blight bacteria in Wisconsin. Burrill is of the opinion that leaf hoppers are the most active agents in disseminating the blight bacteria in Wisconsin. He found them very prevalent throughout the entire season and believes that for Wisconsin at least, they are of greater importance than such species as the tarnished plant bug. In Wisconsin the tarnished plant bug does not occur in abundance on nursery stock until August and Burrill does not correlate this insect with blight infections which appear earlier in the season. Evidently the prevalence of the tarnished plant-bug for any definite time, varies with the locality. Haseman[5] reports this insect as being most destructive in Missouri early in the season. Stewart[6] reports an outbreak of fire blight in two-years-old Kieffer pear trees, which occurred very early in the season, soon after growth started. This epiphytotic of the disease was attributed to the presence of tarnished plant-bugs which were exceedingly prevalent on the pear stock at that time.

From observations made throughout several seasons the writers are of the opinion that all of the sucking bugs found in the nursery are of more

[3] Stewart, V. B. Notes on the fire blight disease. Fire blight favored by a hail storm. Phytopath. **6**: 333–334. 1916.

[4] Burrill, A. C. Insect control important in checking fire blight. Phytopath. **5**: 343–347. 1915.

[5] Haseman, L. Peach "stop-back" and tarnished plant bug. Jour. Econ. Ent. **6**: 238. 1913.

[6] Stewart, V. B. The importance of the tarnished plant bug in the dissemination of fire blight in nursery stock. Phytopath. **3**: 273–276. 1913.

or less importance in producing fire blight infections and must be considered *tout ensemble*. The relative importance of each species is difficult to determine. By virtue of their method of feeding and prevalence during each season, certain species are undoubtedly more destructive than others. On the other hand, under special conditions when a certain species is found in large numbers it may become of considerable importance. Usually the tarnished plant-bug is more injurious than the leaf-hopper from the fact that the greater percentage of leaf-hopper punctures occur in the leaf tissue. Relatively few fire blight infections which originate in the leaf ever extend down the petiole to the twig. For this reason although the leaf-hoppers are very abundant, they may be of less importance in the nursery than insects which feed only on the tender tips of the twigs.

During the summer of 1915 Heald[7] observed in the state of Washington numerous leaf infections caused by *Bacillus amylovorus* on apple and pear trees. He is inclined to believe that the blight bacteria gained entrance to the leaf tissue through the water pores. The writers are of the opinion that for New York State at least, few if any blight infections occur through the water pores of the leaf, an injury of the tissue being necessary for the bacteria to produce infection.

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[7] Heald, F. D. Preliminary note on leaf invasions by *Bacillus amylovorus*. Washington Agr. Exp. Sta. Bul. 125: 3–7. 1915.

NOTE ON APPLE ROOT-ROT IN VIRGINIA

C. H. Crabill

With One Figure in the Text

Root-rot of apples in Virginia is most prevalent in the Shenandoah Valley and in the Piedmont sections. It is very destructive even where the best methods of sanitation and management are practiced. Little is known about it and no attempts have yet been made to control it. Trees affected with root-rot may die at any age but most of those lost are ten to fifteen years old. Young trees set where rotted trees were removed usually die in two to eight years.

The root-rot has been previously described,[1] but the symptoms will be again presented here. The first indication of the disease is a cessation of growth, followed by a loss of some of the foliage then by the death of a portion of the top of the tree. The roots at this time are nearly all dead, punky and brittle and filled with fine white fungus mycelium. The tree can be pushed over readily in nearly every case. The roots break off short near the stump. Deep-lying roots are usually first affected. Growth is then thrown into the more superficial ones, which support the tree for a time. In a short time these roots also die and decay. The wood above the affected roots dies, shrinks and turns brown, due to obstruction of the water supply from the soil.

Observations and reports from orchardists have brought to light the following facts: (1) Root-rot is more prevalent on new ground, especially where the soil contains decaying wood, than on ground which has been cultivated for some years before the orchard was set; (2) root-rot is present on a wide variety of soils and on both steep slopes and low bottom lands; (3) in many orchards several adjoining trees in a group have contracted the disease at about the same time. Around the first tree to succumb, eight or ten additional trees sometimes have died; (4) York Imperial is most susceptible to this disease. Stayman Winesap, Ben Davis, Yellow Newton (Albemarle Pippin) and Arkansas (Black twig) are apparently susceptible in the order named.

In all typical cases of root-rot the roots have been found invested with a delicate white mycelium. Sometimes the surfaces of the roots are cov-

[1] Reed, H. S., and Crabill, C. H. Notes on plant diseases in Virginia observed in 1913 and 1914. Virginia Agr. Exp. Sta. Tech. Bul. 9. 1915.

ered with white to brownish rhizomorphs which branch profusely forming fan-shaped growths which adhere rather loosely to the bark. Some of these rhizomorphs were washed thoroughly by decantation and small pieces thrust into starch agar. Out of fourteen cultures thus made, twelve were pure cultures of a fungus which was tentatively classed as an Acrostalagmus but which was later identified by Mrs. Flora W. Patterson as *Trichoderma koeningi* Oudemans. The other two were contaminated by bacteria.

Following this, roots from trees showing typical symptoms of root-rot were collected in various parts of the state. In each case the root was trimmed, washed thoroughly in tap water, then in bichloride of mercury,

FIG. 1. Apple tree roots affected with root-rot. Photograph by H. S. Reed.

1–1000, and split open with a sterile knife. With sterile forceps bits of the inner wood were picked out and thrust into starch agar in Petri dishes. Every root thus far examined has yielded Trichoderma.

After taking out the material for inoculation of the plates all of these roots were placed in moist chamber. Trichoderma fruited abundantly on all of them. On one of the roots from Middletown, *Hydnum* sp. as well as Trichoderma produced spores. The root from Greenwood yielded, in addition to Trichoderma, a fungus which has not yet produced spores and which has not yet been identified.

The roots from Fishersville were small and still alive. On the wood, immediately under depressed areas of bark, were some oval darkened lesions with raised margins. When placed in moist chamber Trichoderma fruited abundantly on these lesions.

The average rate of growth of Trichoderma on starch agar at ordinary temperatures has been one centimeter every fifteen hours. This unusual rapidity of growth corresponds well with the sudden death of infected trees.

Trichoderma koeningi has been found to grow well on all culture media except those containing an excess of alkali. Lime or ground limestone is very detrimental to its growth. On fresh and well-rotted manure and on composted soil it made a rapid growth and produced abundant spores. On cellulose agar it grew poorly and fruited sparingly. Copper sulphate, 0.1 per cent, added to agar stimulated sporulation.

TABLE 1

Thrust cultures from rotted roots

DATE	LOCALITY	NUMBER OF CULTURES	TRICHODERMA	HYDNUM	CONTAMINATED BY BACTERIA	STERILE
1915						
April 5	Middletown	14	14			
April 12	Middletown	10	1	7		2
July 6	Roselands	10	6			4
July 6	Pleasant Valley	26	12		11	1
July 16	Fishersville	24	16		5	3
July 28	Greenwood	16	14		2	
July 28	Greenwood	16	9		5	2
Totals		116	72	7	23	12

Stained razor sections of typically affected roots show the fungus present in all the xylem elements. The pitted ducts are packed with the mycelium. The smaller wood cells are penetrated and the walls disintegrated. The cell walls are rendered very brittle. The mycelium is inter- and intracellular growing in all directions through the wood.

The facts presented above point to the conclusion that *Trichoderma koeningi* is the cause of a destructive apple root-rot in Virginia. While this organism may behave on apple only as a wound parasite there is some evidence that it is a parasite. Assuming that such is the case, the ability of this fungus to grow on dead organic matter, to spread by wind-blown spores or infected soil and to attack apple trees, make it a most formidable enemy of the apple industry in Virginia

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A TROUBLESOME DISEASE OF WINTER TOMATOES

J. E. Howitt and R. E. Stone

In the spring of 1914 tomato plants showing a marked diseased condition of the leaves, stems and fruit were sent to this department by a tomato grower living in the outskirts of Hamilton, Ontario. A visit was paid to the grower's forcing houses, and the disease was found scattered throughout two large houses, about 10 per cent of the plants being affected. The following December (1914) the trouble again appeared in one of these houses, and some three thousand plants were so badly diseased that the crop was a complete failure. The spring crop of 1915 in the same house was not seriously affected but many plants scattered here and there throughout the house showed clear evidence of the disease. The same spring some diseased plants were found in forcing houses in the vicinity of London and Toronto, Ontario. In August, 1915, the disease was observed on field tomatoes in two localities near Toronto, Ontario, about 1 per cent of the plants being affected.

The disease does not appear to be confined to Ontario. Bailey[1] describes a disease which he calls Winter Blight of Tomatoes. The symptoms given by Professor Bailey for this trouble in many respects strongly suggest that it may have been similar to the disease found in Ontario. Selby[2] described a blight of forced tomatoes which seems to the writers to be similar, if not identical, with the disease in Ontario. Tomato plants showing the characteristic symptoms of the disease were therefore sent to Professor Selby for examination. These were examined by one of Professor Selby's assistants, Mr. A. S. Orcutt, who reported as follows:

"Upon examining the tomato material, and later conferring with Professor Selby, it is our opinion that this is the same trouble which was reported from this section in 1896."

The same disease is also apparently found in the vicinity of Philadelphia. In January, 1915, diseased plants from forcing houses near Philadelphia were kindly sent to the writers by Mr. C. R. Orton, Plant Pathologist of the Pennsylvania State College. These when carefully examined, were found to have spots and lesions on the stems, leaves and fruits characteristic of the disease as it occurs in Ontario.

[1]Bailey, L. H. Some troubles of winter tomatoes. Cornell Univ. Agr. Exp. Sta. Bul. 43: 149-158. 1892.

[2]Selby, A. D. A blight of forced tomatoes. Ohio Agr. Exp. Sta. Bul. 73: 237 241. 1897.

SYMPTOMS OF THE DISEASE

This disease affects the leaves, stems and fruits. It is usually first observed on the young leaves of the terminals. Affected leaves show distinct brown and blackened areas scattered between the larger veins. These are angular, or somewhat diamond shaped, and are usually so numerous and close together that a distinct pattern is seen when affected leaves are held up to the light. An examination with a hand lens reveals the fact that the discoloration is not confined to the mesophyll of the leaf but extends to the secondary veins, and in some cases to the primary veins, so that a browning and blackening of the vascular bundles is clearly evident.

Affected leaves do not develop normally. They at first appear somewhat stunted and, as the disease progresses, droop and finally wither and die. In most cases observed the disease appeared to start on the upper younger leaves and gradually work downward to the older leaves.

On the stems of affected plants brown lesions are usually seen. These vary in size from mere specks to well-marked areas from 1 to 3 cm. long and about half as wide. They are not confined to any particular part of the stem, but are scattered throughout its length, being found just below the base of the petioles of affected leaves, at the base of healthy leaves, and frequently on the internodes some distance from the leaves. If cross sections of affected stems are examined under the hand lens the lesions are found to be almost entirely superficial, the discoloration being confined to the epidermal cells and to the outermost cells of the cortex. Many of these lesions were examined carefully by the writers, but in no case did the discoloration appear to extend into the vascular bundles, the lesions always appearing isolated and local. Professor Jones of the Bacteriological Department, however, reports that on examining some badly diseased plants, he found that the discoloration of the lesions appeared to extend into the vascular bundles.

Diseased fruits are characterized by brown sunken spots scattered irregularly over the surface and not confined to stem or blossom end. These vary very much in shape and size. They may be circular, oblong, angular or irregular in outline, and may be from less than a millimeter to 8 or 10 mm. in diameter. The surface of the spots may be smooth and unbroken, or cracked and scabby. Frequently the spots coalesce so that considerable of the surface of the fruit is brown and scabby. Often these diseased areas are chiefly confined to the grooves between the ridges on the surface of the fruit. Some of the spots are merely superficial, the discoloration not extending to any extent into the flesh of the fruit, while from others the discoloration extends deeply into the fruit and can be traced from the epidermis along the septa to the centre. If diseased fruits mature, the

affected areas fail to color normally and remain hard and green. Very frequently the diseased fruit falls without coloring. When the spots or lesions are well developed, the fruit is frequently more or less deformed, being spotted and scabby to such an extent as to render it useless for market purposes. When diseased fruits were removed from the plants and placed in a moist chamber, the spots failed to develop farther.

ATTEMPTS TO DISCOVER THE CAUSAL ORGANISM

When the diseased plants were received a superficial examination disclosed the blackening and browning of the vascular bundles of the leaves. This symptom suggested that the trouble might be the brown rot of tomatoes caused by *Bacillus solonacearum* E. F. S. Microscopic examinations were made but no fungus or bacteria were found associated with the lesions on leaves, stems or fruits. Dilution plate cultures were made but nothing was found to which the disease could be attributed. Fearing that in some way our technique might be at fault, specimens of diseased plants were submitted for examination to Dr. Erwin F. Smith, Bureau of Plant Industry, Washington, D. C.; Prof. A. D. Selby, Agricultural Experiment Station, Wooster, Ohio; Dr. E. A. Bessey, Michigan Agricultural College; and Prof. D. Jones of the Bacteriological Department of Ontario Agricultural College. All of these gentlemen kindly examined the material supplied and reported the results of their findings. None of them found any organism capable of producing the disease.

EXPERIMENTAL WORK

Experiments were performed to determine if the origin of the disease was in the soil. Seed was obtained from the same lot of seed from which the first diseased tomato plants were grown. This seed was sown in fresh soil in which tomato plants had never been grown; the disease did not appear among the seedlings grown in this soil.

Soil was then obtained from the forcing house in which the disease first appeared. Part of this soil was sterilized, and this portion will hereafter be designated as sterilized soil. Part of soil was left unsterilized and will hereafter be designated as suspected soil. In addition soil which had never grown tomatoes was used and this will hereafter be designated as normal soil.

Seedlings grown in normal soil were then transplanted into three kinds of soil, namely, suspected soil, sterilized soil and normal soil. The plants transplanted to sterilized soil and normal soil all developed normally and produced sound fruit. Some of the plants transplanted to suspected soil were killed by the fungus Rhizoctonia but the remainder remained healthy

and produced sound fruit. The plants attacked by Rhizoctonia did not show any symptoms of the disease in question.

The above experiment was varied. Some of the same lot of seed used in the previous experiment was sown in suspected soil and some in normal soil. The disease did not appear in the seed-beds. Seedlings from the suspected soil and some from normal soil were then transplanted, some from each seed-bed into suspected soil, some into sterilized soil and some into normal soil so that six different combinations were obtained, namely, (1) Seedlings from suspected soil to suspected soil; (2) seedlings from suspected soil to sterilized soil; (3) seedlings from suspected soil to normal soil; (4) seedlings from normal soil to suspected soil; (5) seedlings from normal soil to sterilized soil; (6) seedlings from normal soil to normal soil. Six plants were used in each combination. The results were briefly as follows:

(1) Four of the plants developed the disease when the seedlings were grown in suspected soil and transplanted to suspected soil.

(2) Two plants developed the disease when the seedlings were grown in suspected soil and transplanted to sterilized soil.

(3) Two plants developed the disease when seedlings were grown in suspected soil and transplanted to normal soil.

(4) One plant developed the disease when the seedlings were grown in normal soil and transplanted to suspected soil.

(5) No plants developed the disease when seedlings were grown in normal soil and transplanted to sterilized soil.

(6) No plants developed the disease when the plants were grown in normal soil and transplanted to normal soil.

The interesting point to note in this experiment is the fact that the only plants which developed the disease were those which at some time had been grown in suspected soil, that is unsterilized soil in which diseased plants had previously grown. This experiment, while by no means conclusive, suggests that the origin of the disease may be in the soil.

INOCULATION EXPERIMENTS

A sterilized needle was inserted into diseased lesions of affected plants and then inserted into stems and leaves of healthy plants. Five plants were so treated. The plants were kept moist but no infection resulted. Checks were also free.

Portions of infected plants were enclosed with healthy plants under a bellglass. These were thoroughly sprayed with water in order to ensure a copious supply of moisture. No infection resulted.

Attempts were made to isolate fungi or bacteria from diseased tissue. Both acid and neutral agar were used as media. No fungi developed in

either. In the neutral agar a few bacteria developed. Some of these bacteria were introduced into the tissue of healthy plants by needle punctures and some were smeared upon the leaves and stems and the plants kept moist. The results were negative. This series of experiments was repeated, but again only negative results were obtained.

EXPERIMENTS WITH HYDROCYANIC ACID GAS

It was suggested by tomato growers that the diseased condition might be due to fumigating the forcing house with hydrocyanic acid gas to destroy the white fly. Attempts were therefore made to produce the disease by such fumigation. Tomato plants, both dry and with the leaves sprinkled with water, were placed in an air-tight box and fumigated with hydrocyanic acid gas. Four different strengths were tried, namely, one-third, one-half, two-thirds and one ounce of potassium cyanide per thousand cubic feet. Eighteen plants were used in each trial, nine dry and nine with the leaves sprinkled with water. None of the plants developed the diseased condition, but those fumigated with hydrocyanic acid gas of the strength of one ounce of potassium cynide to a thousand cubic feet of air space had the leaves badly burned.

SUMMARY

1. This disease is widespread and may result in serious loss.

2. Little is known as to the cause of the disease.

3. Repeated microscopic examinations and plate culture tests with various media have failed to disclose a causal organism.

4. Inoculation experiments have given negative results.

5. The position and nature of the lesions and the fact that the disease fails to develop further in affected fruits when these are removed from the plants and placed in a moist chamber indicates that this is a so-called physiological trouble.

6. Experiments with hydrocyanic acid gas indicate that fumigation does not cause the disease.

7. Experiments in sterilized soil seem to indicate that the origin of the disease is in some way connected with the soil, but as no causal organism has been found it would seem that the disease might be due to some chemical or physical deficiency in the soil, which is apparently overcome by sterilization.

8. This account of this disease is published with the object of again calling the attention of plant pathologists to it with the hope of stimulating discussion and research regarding its cause and control.

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RESISTANCE IN TOBACCO TO THE ROOT-ROT DISEASE

JAMES JOHNSON[1]

WITH SIX FIGURES IN THE TEXT

The differences in varietal susceptibility of tobacco to the root-rot disease, caused by *Thielavia basicola* Zopf, has been noted since the time of the discovery of this disease by Peglion in 1897. The possibility of producing resistant strains within susceptible varieties first came to the writer's attention in 1913. The prevalence of the disease in the tobacco fields of Wisconsin and Ontario, Canada, during that season, gave a good opportunity for the study of the nature of the trouble, and particularly favorable conditions for the selection of parent plants for disease resistance. Some of the results obtained in the past two years from a comparative study of the relative resistance of these selected strains and of certain varieties are thought worthy of publication at this time. It is expected that the problem will be continued and, consequently, the details of the work will be left for future presentation. For reasons of convenience a brief description of the nature of the disease, its occurrence, and economic importance is added.

NATURE OF THE DISEASE

Root-rot, or black-root, of tobacco is caused by the fungus *Thielavia basicola* Zopf. Plants affected with this fungus, which attacks only the roots, are characteristically stunted more or less in growth (fig. 1). The degree of stunting may vary from hardly perceptible decreased vigor to complete retardation of growth. Complete destruction of the plants occurs but rarely. In the former case the disease may be more injurious to quality than to yield, as is indicated by more or less marginal curling of the upper leaves and premature yellowing and death of the lower leaves. Crops often recover from serious early attacks of the disease, which, how-

[1] *Acknowledgments.* The opportunity to carry on work in the Burley sections of Canada was made possible by the Imperial Tobacco Company of Montreal. The study of the occurrence and importance of the disease in various parts of the United States was done in cooperation with the Office of Tobacco Investigations, U. S. Department of Agriculture. The writer is indebted to Dr. L. R. Jones, Pathologist at the Wisconsin Experiment Station, Mr. T. S. Biggar, Superintendent of the Walker Sons Farms, and to Officials at the Harrow Experimental Farm, Ontario, Canada, for advice and assistance.

ever, result in late growth and maturity, thus directly injuring the quality or causing increased possibilities of damage by frost or of curing and packing-house troubles. Complete crop failure sometimes occurs, but more often what may be called half-crops are harvested.

In bad cases of the disease the root system is characteristically deficient. Only two or three small new roots may be present on such plants. These roots function for a short period of time, only to be attacked by the

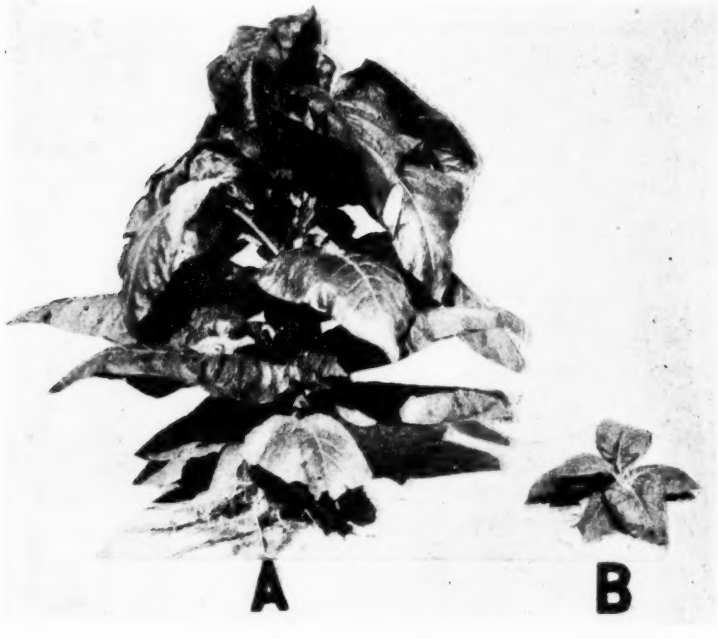

FIG. 1. Showing stunted growth of White Burley tobacco due to the root-rot disease. Walkerville, 1914. *A*, Normal White Burley grown on healthy soil; *B*, diseased White Burley plant grown on diseased soil about one rod distant. Both plants grown in same row and from self-fertilized seed of same parent plant. Age of plants in field about eighty days.

parasite, and replaced by other new roots, by means of which the plant is enabled to maintain life. In less serious cases all the primary and secondary roots may be present, but show local areas attacked by the fungus. Such areas usually girdle the roots, are brown or black in color, scabby in appearance and frequently are hypertrophied. The tertiary roots, however, may be badly decayed on such plants, a condition which results in a markedly stunted growth. On the other hand, it appears that practically all the roots may be present, but, owing to small local

infections, the roots are unable to function properly, with resulting evidences of starvation in the leaves.

On the whole, the above-ground symptoms are characteristic of such conditions as may be brought about by lack of fertility or of water in the soil. The condition of infected fields, therefore, is often attributed erroneously to some form of malnutrition.

OCCURRENCE OF ROOT-ROT

Thielavia basicola has been known for some time as a common parasite on tobacco in Italy and in the United States. It has also been reported upon tobacco in Sardinia and in Cuba, and as occurring upon other plants in Germany, Russia, England, Belgium, and Korea.

In the United States it has been reported previously upon tobacco in Ohio, Connecticut, Kentucky and North Carolina. It has also been reported on violets, ginseng and other plants in Connecticut, Maryland, New York, Ohio, Pennsylvania, Vermont, Wisconsin, Michigan, Minnesota, Indiana, Illinois, Nebraska, Utah, and the District of Columbia. More recently it was reported by the writer[2] as a serious disease of tobacco in Wisconsin and Ontario, Canada. In 1915 the Thielavia disease was observed by the writer in Ohio, Kentucky, Pennsylvania, Connecticut and New York, in which states it appeared to be a most important factor in controlling crop production. In addition, the disease was found on specimens of tobacco from Virginia, Maryland, and Massachusetts. The occurrence and importance of this disease in the more southern tobacco fields remains to be ascertained. According to Dr. W. W. Garner, of the Bureau of Plant Industry, United States Department of Agriculture, the Thielavia root-rot occurs, however, in Florida, causing a very considerable amount of damage to shade-grown tobacco.

ECONOMIC IMPORTANCE OF THE DISEASE

Ordinarily the growers do not recognize the importance of this disease, owing to the obscurity of the infected parts, and the similarity of the symptoms in the aerial parts to the effects of impaired nutrition. Hence, the losses are generally attributed to such causes as soil sickness, soil deterioration, loss of fertility, excess or lack of water supply, or to the improper physical condition of the soil.

The root-rot disease appears to be especially prevalent in sections where the tobacco is grown upon the heavier types of soil, as in Wisconsin,

[2] Johnson, J. Resistance in Tobacco to Root-rot, (Thielavia basicola, Zopf.). Phytopath. **4**: 48. 1914.

Ohio, Kentucky, Pennsylvania, New York, and parts of Canada. On the other hand, during wet seasons, very considerable damage may result on such light, sandy soils as those of the Connecticut Valley.

It seems probable that the root-rot disease is responsible in a large measure for the maintenance, if not for the development, of the present system of tobacco culture in the Burley sections of Kentucky and other states. This system of culture, which for best results requires a period of rest of five to ten years for the soils between crops of tobacco, appears to have been empirically developed in Burley tobacco culture, owing to the extreme susceptibility of this variety to the root-rot disease. Although this practice has made Burley culture possible, there is still a very considerable loss from the disease in the Burley sections. The Burley growers of Canada have not yet recognized the Kentucky system and have experienced increasing difficulty in growing satisfactory crops of this variety. The resting of land for long periods of time, is, however, generally impracticable in the northern tobacco growing sections, owing to the more restricted areas suitable for the culture of this crop.

A reliable estimate of the losses due to the root-rot disease is especially difficult to make. Such figures are of value, however, in giving a general idea of the importance of the disease which cannot be obtained in any other way. The annual losses in the United States certainly run into millions of dollars. The crop of 1915 probably suffered the most of any in the recent history of the disease, owing to the abnormally wet season. The loss conservatively can be placed at between ten and twenty millions of dollars for this year in the United States alone.

EARLIER WORK ON RESISTANCE IN TOBACCO

The root-rot of tobacco (*Thielavia basicola* Zopf.) was first reported by Peglion[3] in Italy in 1897, who noted at the same time a difference in varietal susceptibility. He noted particularly that the "Seed-leaf" type was much less damaged than the "Kentucky-Burley." Peglion recognized the disease as serious and recommended that varieties be studied in order to determine differences in resistance. Apparently following this investigator's recommendation, the study of varietal resistance to root-rot has been reported upon by several writers from Italy, but as far as known has not been worked upon in this country, although it was suggested as a possible means of control by Gilbert[4] in 1909. The Italian experimenters

[3] Peglion, V. Marciume radicale delle piantine di tabacco causato dalla Thielavia basicola, Zopf. Centralbl. Bakt., etc., **3**: 580–584, (1897).

[4] Gilbert, W. W. The Root-rot of Tobacco caused by Thielavia basicola, Zopf. U. S. Dept. Agr. Bur. Plant Indus. Bul. 158: 9–43. 1909.

have been concerned mainly in comparing the resistance of varieties and hybrids, and apparently have not concerned themselves with producing resistant strains of a susceptible variety. Benincasa[5] in 1902 reported the native varieties of Italy more resistant to root-rot than the foreign varieties and noted that the Burley variety was the most susceptible of the introduced varieties. In contrast to the Burley he found a variety, Brasile Beneventano, to be particularly resistant and placed some other varieties in the order of their resistance to the root-rot disease.

At about the same time Barbatelli and Stazi[6] stated that the "heavy" tobaccos and hybrids suffer most from this disease, while the "light" tobaccos were only slightly attacked.

Buttaro,[7] also writing in 1902, presumably of the same work as that of Benincasa, notes that the Brasile Beneventano and Kentucky varieties give the best results and Burley the poorest results on infected soils. In a later note this writer[8] adds that as a result of an exceedingly wet season, the disease not only attacked the exotic varieties, but also the native variety Brasile Beneventano.

Benincasa[9] in 1911, writing further upon control measures against the root-rot disease, reports the trouble especially prevalent on the Kentucky tobacco, and recommends that the growers substitute a new strain of Kentucky for the pure Kentucky. A cross between the "Salento" and "Italia" varieties is said to be resistant to root-rot in the seed-bed and in the field, at the same time having other desirable qualities.

Aielli-Donnarumma[10] some time later reports upon the results of five years' investigation along this line. Numerous crosses were made between the "Kentucky," "Italia," "Moro," and "Salento" varieties, in an attempt to bring out resistant types. One hybrid, "Italia × Kentucky B," was developed which was apparently strikingly resistant to the root-rot disease. Other types, "Moro × Kentucky," and "Salento × Kentucky," were next best, but were, however, subject to attack from the fungus.

[5] Benincasa, M. Ricerche sui mezzi per difendere i semenzai di tabacco dal "marciume radicale" causato dalla Thielavia basicola, Zopf. Bol. Tecnic. d. coltiv. d. Tabacchi, **1**: 24–33. 1902.

[6] Barbatelli and Stazi. Notizie sull'andamento delle coltivazioni e cure dei Tabacchi. Scafati. Bol. Tecnic. d. coltiv. d. Tabacchi, **1**: 152. 1902.

[7] Buttaro, G. Notizie sull'andamento delle coltivazioni e cure dei Tabacchi. Pontecorvo. Bol. Tecnic. d. coltiv. d. Tabacchi, **1**: 159. 1902.

[8] Buttaro, G. Notizie sull'andamento delle coltivazioni e cure dei Tabacchi, Pontecorvo. Bol. Tecnic d. coltiv. d. Tabacchi, **1**: 234. 1902.

[9] Benincasa, M. I semenzai di sabbia considerati quale mezzo di difesa contro il marciume radicale causato dalla Thielavia basicola, Zopf. Bol. Tecnic. d. coltiv. d. Tabacchi, **10**: 3–22. 1911.

[10] Aielli-Donnarumma. Meticci pesanti refrattori alla Thielavia al campo. Bol. Tecnic. d. coltiv. d. Tabacchi, **10**: 277–281. 1911.

Aielli-Donnarumma has in later notes[11] reported some of these resistant hybrids as satisfactory for commercial purposes in Italy. One of the Italia × Kentucky hybrids, in particular, gave good yield and quality on diseased soil. Later this same writer[12] reports excellent results in crossing two resistant hybrids in order to intensify the resistance and improve the quality.

Benincasa[13] published a paper in 1914 on some further observations of the root-rot disease. In this paper it is stated that the Burley, Kentucky, and Virginia types are the most susceptible, while the indigenous races possess considerably more resistance. Some of the small and eastern races of tobacco are also noted to be resistant.

Shamel and Cobey[14] noted resistance in tobacco to a "wilt" disease, and to the root-knot disease in the United States sometime previous to 1907. The latter disease is apparently erroneously referred to by Waite[15] as the root-rot disease in a general paper on disease control.

In 1913 a brief notice regarding the relative susceptibility of the Little Dutch, Connecticut Havana, and White Burley varieties to the Thielavia disease was published by the writer.[16]

METHODS OF WORK

The experimental work of testing varieties and strains has been performed in several different soils and localities. Most of the tests have been duplicated at least twice under different conditions and some trials have been repeated four or five times. The Burley work has been confined mainly to Ontario, Canada, and the cigar leaf selections to Wisconsin, although many Burley strains have been grown in Wisconsin and some cigar leaf strains in Canada.

In Canada the greater part of the work has been done at the Walker

[11] Aielli-Donnarumma. Risultati attenuti circa le destrivazioni d'impiego dai prodatti di meticci pesanti resistenti alla Thielavia basicola nel 1911. Bol. Tecnic. d. coltiv. d. Tabacchi, **11**: 286. 1912.

—— Risultati economici attenuti dalla coltura di meticci pesanti resistenti alla Thielavia basicola. Bol. Tecnic. d. coltiv. d. Tabacchi, **12**: 89. 1913.

[12] Aielli-Donnarumma. Su due combinati di tabacchi pesanti. Bol. Tecnic. d. coltiv. d. Tabacchi, **13**: 7–8. 1914.

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Sons' Farms, Walkerville, Ontario. On this farm, where two or three hundred acres of tobacco are grown annually, the soil has been made extremely fertile by the use of animal manures, but has become so badly infected that Burley growing is commercially impossible, and more resistant varieties of dark tobacco are grown. Plots have been located also at the Dominion Experimental Farm at Harrow, and at Mr. A. Leslie's farm at Kingsville, at which places the soil is of a light, sandy nature and moderately fertile. In Wisconsin the plots have been located on a silt loam soil at the Experiment Station Farm, Madison, and on a clay loam soil at Edgerton.

The varieties used in the tests have been obtained from the most reliable sources. Most of the seeds have been secured from the United States Department of Agriculture, Office of Tobacco Investigations. Others were obtained from various experiment stations in this country and Italy, or from reliable seed growers and distributors. The selections for disease resistance within varieties were made in Ontario for the White Burley type and in Wisconsin for the cigar leaf types. A large number of fields, involving in the neighborhood of two thousand acres, were scrutinized in these sections for resistant parent plants. Where out-standing plants were found the seed-heads were bagged to insure self-fertilization and the plants labelled and numbered. Short notes were taken as to the desirability of the type and its superiority over the neighboring plants. In this manner forty-eight Burley selections and forty-two cigar leaf selections were originally made. The seed from each plant was saved separately and sown in separate plots of sterilized soil. When these plants were of the ordinary size for transplanting they were set into infected soil in progeny rows. Types of the most resistant and the most susceptible varieties were usually set in all plots as checks.

At intervals throughout the growing season estimates were made of the relative growth of the types, using 100 per cent as a basis for normal growth, usually represented by the most resistant type in the plot. Most of the data collected exist in the form of estimates, which were found to be fairly reliable when compared with computed relative yields from actual weights. Owing to the large number of cultures used it was found impossible to get the actual yields of cured leaves from each type and, moreover, many of the types never reached sufficient size or maturity to harvest for curing. In 1915 the green weight of the leaves and stalks of twenty-five plants from many of the types were taken for comparison, and these figures form the basis of this paper. In order to reduce the error likely to result from differences in vigor of growth of the types, the green weight of twenty-five plants of each type as grown on uninfected soil was also taken. The relative yield on infected soil is then computed on the basis of these

figures, which can be taken as a fairly close approximation of the relative resistance on each plot. The actual resistance can not be computed in this way since the result will naturally vary with the fertility of the uninfected soil, and the fertility and amount of fungus in the infected soil.

VARIETAL RESISTANCE

Varieties are frequently based upon somewhat small and unsatisfactory differences. Sub-varieties, local varietal names, and local strains are

TABLE 1

Comparative yield of tobacco varieties on uninfected and infected soil. Madison, Wisconsin, 1915

VARIETY	GREEN WEIGHT OF TWENTY-FIVE PLANTS		RELATIVE RESISTANCE
	Uninfected soil	Infected soil	
	pounds	*pounds*	*per cent*
White Burley	66.5	3.0	4.5
Comstock Spanish	59.5	20.0	33.6
Connecticut Havana	45.0	20.75	46.1
Kentucky Greenleaf	49.75	3.0	6.0
Pennsylvania Broadleaf	82.5	14.0	16.9
Brasile Beneventano	56.6	41.25	73.0
Maryland Broadleaf	65.0	2.5	3.8
Italia × Kentucky	60.0	39.5	65.8
Big Oronoco	57.75	3.0	5.2
Ohio Seedleaf	70.5	15.25	21.6
Yellow Pryor	59.0	2.5	4.2
Black Seedleaf	84.25	23.25	27.6
Halladay Havana	58.5	33.25	56.8
Gregory's White Burley	59.75	1.75	2.9
Little Dutch	79.50	40.0	50.3
Montgomery Seedleaf	93.50	44.0	47.0
Maryland Narrowleaf	66.50	2.25	3.3
Cuban	28.25	5.25	18.5
Northern Hybrid	65.0	45.5	70.0
Golden Spanish	50.0	25.5	51.0
Silver Leaf	56.25	31.5	56.0
Page's Comstock	41.25	32.5	78.7
Pease Seed	49.0	37.25	76.0

very commonly confused among the growers as true varieties. Since any method of classification is necessarily arbitrary, the commercial names have been adhered to regardless of biological relationships. An endeavor has been made to include the important commercial varieties of the United States, the important strains of Burley tobacco as grown in

Kentucky and Ontario, and the important commercial types of cigar leaf tobacco as grown in Wisconsin. Two types, Brasile Beneventano and Italia × Kentucky, developed for disease resistance in Italy, have been included for comparison.

The relative yield of most of these types on uninfected and infected soil is shown in table 1. Reference to the column "Relative resistance" shows that a marked variation exists in the range of susceptibility of these types to the root-rot disease (fig. 2). Unfortunately, the varieties showing most resistance to disease are among the least extensively grown or are undesirable in quality for the purpose for which they are intended. Since there are fully eight or ten different types of tobacco grown for as many different purposes it consequently will be necessary to develop a resistant strain for each of these types, which will be satisfactory both as

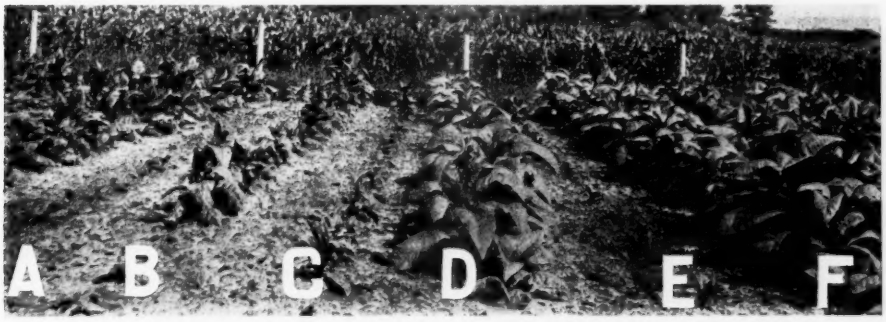

FIG. 2. Differences in varietal resistance to root-rot. Madison, 1915. *A*, Yellow Pryor; *B*, Ohio Seedleaf; *C*, Big Oronoco; *D*, Italia × Kentucky; *E*, Maryland Broadleaf; *F*, Brasile Beneventano.

to yield and quality. White Burley is one of the most extensively grown types and also one of the most susceptible, consequently the greatest interest centers around selections in this variety.

THE WHITE BURLEY SELECTIONS

The trials with White Burley have consisted in testing out the major portion of the forty-eight parent plants selected for resistance in Ontario in 1913, and in comparing the best local strains of White Burley grown in the the United States and Canada. In dealing with White Burley as grown in Canada it was found that on the whole the types were not uniform in the field. Frequently as high as one to two per cent of the plants in the field did not have the color characteristics of the White Burley. The stalks, midribs and veins on these plants were decidedly green and not creamy

FIG. 3. Showing resistance of "green Burley" type to root-rot. Walkerville, 1914. *A*, Burley selection (P705) green; *B*, White Burley (Strain Broadleaf); *C*, White Burley Selection (JS05).

FIG. 4. Showing effect of selection on development of resistance to root-rot within the White Burley variety. Madison, 1915. *A*, White Burley selection, (P701B); *B*, Ordinary White Burley.

white as is characteristic of these parts in normal White Burley. These "off-type" plants are ordinarily called "mongrels" or "green Burleys" by the growers. It was also evident that these green Burleys were usually much more resistant to disease than the ordinary White Burleys (fig. 3). Some of the most resistant green Burley types were selected with the idea that they might throw off resistant true or White Burleys. A few of these green Burleys bred uniformly resistant and true to type, while others

TABLE 2

Comparative yield to tobacco on uninfected and infected soil. Ontario, Canada, 1915

NUMBER	VARIETY OR STRAIN	GREEN WEIGHT OF TWENTY-FIVE PLANTS		RELATIVE RESISTANCE
		Uninfected soil	Infected soil	
		pounds	*pounds*	*per cent*
1913	Halley's White Burley	49.0	0.25	0.5
B1197	White Burley Selection	41.5	14.25*	34.3
B1198	White Burley Selection	47.5	18.0	37.9
B1193	White Burley Selection	57.5	24.5	42.6
J80312	White Burley Selection	42.5	7.0	16.4
J80314	White Burley Selection	31.5	2.5*	7.9
J803B	White Burley Selection	42.0	7.0	16.6
B121	Broadleaf Standup Burley	60.0	7.25	12.0
B1211	Broadleaf Standup Burley	69.5	6.75	9.7
1910	Gregory's White Burley	78.0	0.50	0.6
P701B	White Burley Selection	69.0	8.0	11.6
1924	White Burley Selection	79.0†	9.5†	12.0†
1925	White Burley Selection	41.0	6.0	14.6
B1092	White Burley Selection	72.0	0.25	0.3
B1131	Thompson's White Burley	62.0	0.50	0.8
S6207	Pryor Selection	45.0	2.0	4.4
S6161	Pryor Selection	47.5	3.5	7.3
S6041	Pryor Selection	50.0	2.5	5.0
	Barnard's White Burley		0.25	
1919	Connecticut Broadleaf		17.75	
H12031	Cigar Leaf Selection		33.0	

* Outside row. † Green Burley type.

split up into green and white Burleys, some of the latter showing marked tendencies toward resistance. Further selections with true Burleys developed from this source have proved to be the most resistant of any strains obtained. Selections B1193 and P701B are representative of this type (table 2 and fig. 4). The former is, as far as can be determined in the field, a normal White Burley type with a resistance which is, in some cases, over one hundred times greater than ordinary Burley on very badly diseased soil. Selection P701B is seemingly not yet fixed in type,

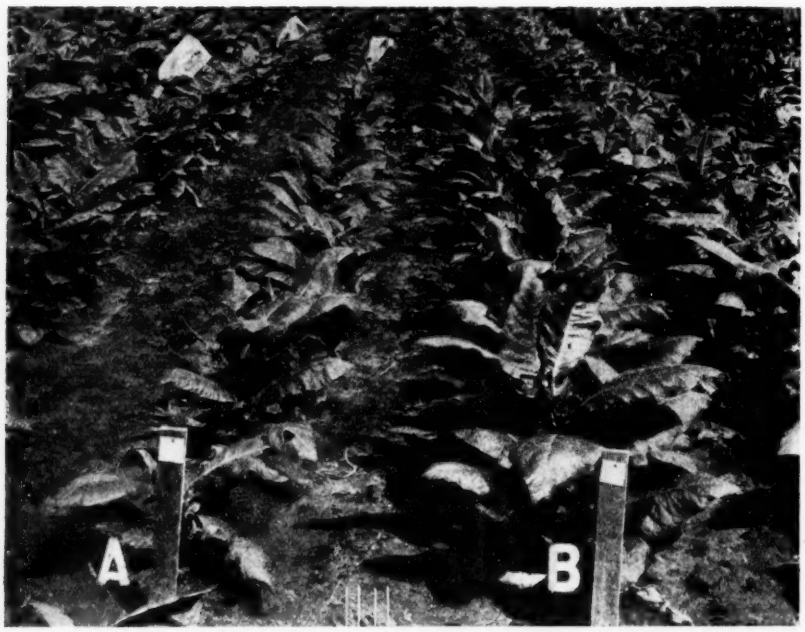

FIG. 5. Relative resistance of two cigar leaf strains selected for resistance from a grower's field. Illustrates cause of uneven growth in diseased fields when impure seed is used. Madison, 1914. *A*, Cigar Leaf Selection 1403; *B*, Cigar Leaf Selection 1401.

FIG. 6. Relative resistance of White Burley strains. Walkerville, 1914. *A*, Burley Selection (J803); *B*, White Burley (Stoner Strain); *C*, Burley Selection (B119) from which best Burley strain (B1193) was obtained.

but promises to be as good as or better than selection B1193. Selection J803 came directly from a fairly good Burley parent and possessed considerable resistance from the start, but it is not as promising as B1193 in either quality or resistance.

From the twenty local strains of White Burley grown in the Burley sections, only one exhibited any degree of resistance. This was a strain known as Broadleaf Standup Burley, which probably was empirically developed as a semi-resistant type.

CIGAR LEAF TOBACCO SELECTIONS

The cigar leaf tobacco selections have been confined practically to this type as grown in Wisconsin for cigar binder purposes. The two varieties commonly grown in this state are Comstock Spanish and Connecticut Havana, both of which are practically identical with the Havana Seed type as grown in Connecticut. These types are losing favor with the growers on account of the fact that they give small yields on old tobacco soils, apparently regardless of fertility. The result has been the introduction of a number of coarser-growing types which are in some cases regarded as inferior in quality by the manufacturers, but usually give satisfactory yields from the grower's standpoint. The advantage of these coarser types (locally known as Seedleaf, Big Seed, Hybrid, and so forth) is now known to be due to their more marked resistance to disease. In table 1, Page's Comstock, Pease Seed and Northern Hybrid are representative of this type. On uninfected soil these types yield on the average no more than the Comstock Spanish or Connecticut Havana varieties.

The striking unevenness in size of plants frequently observed throughout infected fields of both cigar and Burley tobaccos is generally due to the use of impure strains of seed on infected soil (figs. 5 and 6). The same condition can usually be brought about by growing the second filial generation of a cross between a susceptible and resistant type on infected soil. Where known pure strains of seed are grown the plants are invariably uniform as to size in the row, whether a susceptible or a resistant type is grown, except for such variations as may be due to soil-differences. Opportunities for selection of resistant types have, therefore, not been found where pure seed has been used but in fields where mixed types occur. Forty-two parent plants of apparently resistant cigar leaf types were selected from Wisconsin fields in 1913. The seed of most of these were tested out in 1914 and 1915. The relative yield of some of these as grown in 1915 on uninfected and infected soil are shown in table 3. Unfortunately, the infected soil in this case was more fertile than the uninfected soil, so that there was a greater yield on infected soil than on unin-

fected soil for the most resistant types. The relative resistance, therefore, in some of these types rises above 100. Strain H12031 has consistently shown a degree of resistance considerably above any other type of tobacco which has yet been grown.

TABLE 3

Comparative yield of tobacco on uninfected and infected soil. Madison, Wisconsin, 1915

NUMBER	VARIETY	GREEN WEIGHT OF TWENTY-FIVE PLANTS		RELATIVE RESISTANCE
		Uninfected soil	Infected soil	
		pounds	*pounds*	*per cent*
1401	Cigar Binder Leaf Selection	29.25	40.0	136.7
1403	Cigar Binder Leaf Selection	21.50	19.25	89.5
14032	Cigar Binder Leaf Selection	28.25	21.75	76.9
1405	Cigar Binder Leaf Selection	39.25	25.25	64.3
16011	Cigar Binder Leaf Selection	34.25	25.75	75.1
1602	Cigar Binder Leaf Selection	36.50	22.5	61.6
1604	Cigar Binder Leaf Selection	34.50	29.25	84.7
1605	Cigar Binder Leaf Selection	34.0	25.5	75.0
18011	Cigar Binder Leaf Selection	38.0	41.5	109.2
18021	Cigar Binder Leaf Selection	35.0	29.0	82.8
1803	Cigar Binder Leaf Selection	43.0	47.5	110.4
H1201	Cigar Binder Leaf Selection	37.5	39.75	106.0
H1202	Cigar Binder Leaf Selection	25.0	41.0	164.0
H12031	Cigar Binder Leaf Selection	36.0	57.0	158.3
H12035	Cigar Binder Leaf Selection	38.5	60.0	155.6
H1206	Cigar Binder Leaf Selection	37.0	47.75	129.0
H12071	Cigar Binder Leaf Selection	42.25	56.0	132.5
H12074	Cigar Binder Leaf Selection	42.50	56.75	133.5
3330422	Connecticut Havana	36.5	24.5	67.1
	Gregory's White Burley	48.75	3.5	7.1
B1193	White Burley Selection	55.0	29.5	53.6
P701B	White Burley Selection	42.5	32.5	76.4

The quality for commercial purposes of the more resistant of these strains has not yet been determined. Resistant strains with the quality of the Havana Seed are desired. Such types can no doubt be obtained, provided the trials are conducted on a sufficiently extensive scale.

SUMMARY

1. The root-rot of tobacco, caused by *Thielavia basicola* Zopf, is one of the most prevalent and the most serious diseases of tobacco in the United States and Canada.

2. The disease occurs in practically all the northern tobacco-growing sections, and in the Burley-growing sections of the South. Its occurrence and importance in the more southern-growing sections has not yet been determined.

3. The importance of the disease is not ordinarily recognized by the growers owing to the obscurity of the diseased parts, and the similarity of the above-ground symptoms to effects brought on by improper chemical, physical, and moisture relations of the soil.

4. A marked varietal difference exists in resistance to the root-rot disease. Of the standard types, the White Burley, Oronoco, Pryor, and Maryland groups are most susceptible. The Little Dutch and Connecticut Broadleaf are most resistant, while the Havana Seed type occupies an intermediate degree of resistance.

5. A strain of White Burley has been developed which possesses a high degree of resistance to the Thielavia root-rot. On very badly infected soils the yield of this type was in some instances over one hundred times greater than that of the ordinary Burleys.

6. Strains of cigar leaf tobaccos exist and can be isolated which are practically immune to this disease. On the whole, however, the quality of these types for commercial purposes is apparently unsatisfactory. There seems to be no reason, however, why resistant types with desirable qualities should not be found.

7. The production of disease-resistant strains of tobacco promises to become the most satisfactory and most practical method for the control of the root-rot disease of tobacco.

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AN OUTBREAK OF WHITE PINE BLISTER RUST IN ONTARIO

J. E. Howitt and W. A. McCubbin

Cronartium ribicola Fisch. de Waldh., was first observed in Ontario on a young currant plantation at the Ontario Agricultural College, Guelph, in September 1914. The rust was most abundant on black currants, but was also present to some extent on red currants and gooseberries. During the following week it was also found on currants in the Niagara District near Winona.

Though the season was late a survey was commenced to ascertain to what extent the rust was present in the Province generally. It was found in abundance in the region lying along the southern shore of Lake Ontario from the Niagara river to Hamilton, and along the northern shore from Hamilton eastward as far as Oakville. This region, which comprises an area of approximately 350 square miles, is mainly devoted to fruit growing, and therefore currant plantations are numerous and close together. Scattered through this section are also a number of nurseries, in many of which imported white pines are kept in stock. In addition, second-growth white pines are numerous, especially along the escarpment bounding this district on the south. The rust was also found in the Fonthill nursery district lying midway between Lake Erie and Lake Ontario.

In 1915 this survey was continued. The disease was again present during this season in all the areas where it had occurred in the preceding year, and in addition was found on currants in the following counties: Haldimand, Brant, Durham, and Elgin. Of these counties, Haldimand adjoins the main area of infection already noted; Brant is 25 miles from it; while Durham and Elgin are distant about 60 and 120 miles respectively.

The Peridermium stage was found on imported white pines in the following counties—the number of infected trees in each county being stated: Brant (2), Durham (2), Halton (8), Welland (4), Wellington (6), and Wentworth (24). In addition about 200 infections were found in a grove of native pines in Welland County. It is interesting to note that while specimens of *P. cembra* Linn. and *P. parviflora* Sieb. and Zucc. were found in several nurseries, none of these were affected with rust. The evidence appears to be clear that the rust was introduced into Ontario in recent years on white pine nursery stock imported from Europe; from Germany

and probably also from France and Holland. In the majority of cases the individual outbreaks can be connected definitely with the presence of some of these trees in the vicinity.

The following is a list of the species of cultivated and wild Ribes on which *Cronartium ribicola* has been found: *Ribes nigrum*, L., *vulgare* Lam., *grossularia* L., *aureum* Pursh., *cynosbati* L., *triste* Ball., *floridum* L'Her., *prostratum* L'Her.

No records were obtained of the susceptibility of native species, but the degree in which infestation occurs on a number of the cultivated varieties was determined to some extent in the plantations at the Ontario Agricultural College. Black currants, *R. nigrum*, were in all cases found to be more susceptible than other cultivated species, and among these the following varieties were badly attacked: Champion, Naples, Climax, Boskop Giant, and Kerry. Among red and white currants the disease was present on the various varieties to the following extent: Ruby Castle, 24 per cent, Victoria, 21 per cent, Cherry, 14 per cent, Fay, 10 per cent, Red Cross, 5 per cent, Magnus, 4 per cent, London Red, 0 per cent.

Gooseberries appeared to be more resistant than either red or black currants, as only two bushes among several hundred were affected. These two, however, were badly affected with the disease.

From numerous field observations made by the writers it was evident that the rust could pass from currant to currant across an interval of nearly half a mile. In one case this distance was ascertained by actual measurement to be 800 yards, but the occurrence of the disease in many isolated currant plantations gives rise to a strong suspicion that the distance over which infection may be carried is very much greater than this.

The question as to whether currant infection in spring must invariably come from a diseased pine, or whether in some cases it may arise from a wintering over of the fungus on the currant itself, is of such extreme importance that several experiments on this phase of the subject were undertaken.

1. In the fall of 1914 sixteen black and seven red currant bushes and one gooseberry bush, all badly rusted, were stripped of leaves and placed in cold storage, where they remained until March 16, 1915. At this date they were removed and planted in a greenhouse. All grew well and produced healthy leaves and fruit, and were entirely free from rust throughout the summer. In addition seventeen black currant bushes which had been badly rusted in 1914, and which were wintered in the field, were added to the above on April 21, 1915. These also grew normally and without rust.

2. Seventy-eight black currant bushes badly rusted in 1914 were wintered in the nursery rows, and transplanted April 21, in various gardens, isolated

as far as possible from infected white pines and currants. These were inspected six times during the summer, the last inspection being made October 2. At this date all were still free from rust except two bushes, on each of which a few rusted leaves were found. There is reason, however, to suspect that these infections might have been due to spores carried from currants about a mile distant from the garden in which they occurred. In no case was rust found on any of these currants which were located more than a mile from a source of infection.

3. A number of bushes from the same source as No. 2 were planted in five lots in a region known from personal observation to have been entirely free from the rust in 1914, and which is 60 miles from the nearest known source of infection. Of the 100 bushes set out here only one developed rust, and this late in the season. All conceivable sources for this infection have been accounted for except two, viz: the wintering over of the rust on the currant itself, or accidental infection from spores carried on the writer's clothing while making an inspection on May 24.

4. Attempts were also made to produce infection from the rusted leaves of the preceding year wintered out of doors. All such attempts gave negative results.

An endeavor was made to control the rust on currants by the use of bordeaux mixture and soluble sulphur, applied every two weeks throughout the summer. In spite of the exceedingly wet weather encountered, which was conducive to the spread of the disease and at the same time interfered with the effectiveness of the mixtures employed, the results indicate that, while the rust cannot be eliminated entirely by this means, it can be prevented from doing any serious harm to the currant leaves. In this connection it may be noted that while the European currant rust is not regarded by pathologists in general as a serious disease, yet here in Ontario it has for the last two years (1914–1915) been responsible for the early and almost complete defoliation of numerous plantations of black currants. Such defoliation must of necessity decidedly impair the vitality of the bushes.

SUMMARY

1. Currant rust has been found in nine counties in the Province of Ontario.

2. The Peridermium stage has been found on both imported and native white pines, and the Cronartium stage on five cultivated and four wild species of Ribes.

3. Black currant plantations have in many cases been severely injured.

4. Imported white pines have been clearly shown to be the source of infection in the majority of cases.

5. According to observations the rust passes from currant to currant over an intervening distance of at least 800 yards.

6. The results of spraying experiments indicate that the rust on currants can be markedly reduced by repeated applications of bordeaux mixture or soluble sulphur.

7. Some evidence has been obtained which suggests that the rust may possibly winter on the currant, although the majority of tests on this point gave negative results.

In conclusion the writers wish to acknowledge the efficient service rendered in connection with the survey and experimental work with White Pine Blister Rust by Dr. R. E. Stone, Lecturer in Botany, Ontario Agricultural College, who made many of the field observations and experiments and Mr. Alfred Cleeves, Mr. G. O. Madden and Mr. D. R. Sands, field assistants, who examined most of the pine and currant plantations in the counties inspected.

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PRELIMINARY STUDIES ON THE RESISTANCE OF PRUNUS TO ARTIFICIAL INOCULATION WITH BACTERIUM TUMEFACIENS[1]

CLAYTON O. SMITH

WITH PLATE VI

From the studies of Dr. Erwin F. Smith and his associates, came our knowledge of the relation of *Bacterium tumefaciens* to grown gall and of the large number of hosts capable of being infected. All plants, however, did not prove equally susceptible and this suggested that possibly some of the species of Prunus might be much more resistant to the disease than were those the stocks of which are now being used for the various stone fruits. A more resistant stock is needed especially for the various stone fruits, including almonds, because of the following reasons: (1) The disease is widely distributed in orchards and nurseries, and has a deleterious effect on the orchard trees; (2) the most careful examination of such nursery stock before planting fails to eliminate the tree having incipient crown gall; (3) a more resistant stock could be planted in soils which are infected from previous plantings of trees or vines without the danger of contracting the disease as is often the case with the stock now in use.

The plan as finally adopted for determining resistance to crown gall, was to inoculate different kinds of Prunus at intervals of a week from May to September. Ten inoculations by puncture were made on the current year's growth at each test. Both resistant and susceptible kinds were included, as the viability of the culture could thus be known and a comparative test of the relative resistance secured. The organism was grown in pure cultures on standard nutrient agar to which one-half per cent dextrose was added. On this medium a vigorous raised-up growth was formed in sufficient quantities, after twelve to eighteen hours, to be used in making inoculations. No effort was made to protect the punctures in any way, as this was not at that time regarded as necessary. Moreover, the use of wax or other means of protection often causes an enlarged callus-like growth that could be confused easily with enlargements caused by *Bacterium tumefaciens*.

[1] Paper No. 24, Citrus Experiment Station, College of Agriculture, University of California, Riverside, California.

The various species of Prunus were secured from several reliable sources; seeds and scions from the Arnold Arboretum; trees and scions from nurseries, and scions from some of the Experiment Stations. In the experimental work three different strains of the organism were used; number 694 was used in the preliminary work[2] and came from peach seedlings, number 753 was isolated from almond galls on April 14, 1913, and number 790 was isolated in 1914 from a peach gall on a large orchard tree.

In the inoculation experiments, cultures that had been growing in the laboratory for two years, were found to be still viable. Cultures that have been under cultivation for at least a year have been used from choice in the hope that there would be a slight decrease in virulence and hence a better showing of relative resistance in the plants under experimentation. No difference in the behavior and viability of these cultures was observed. Check inoculations showed negative results.

The following are the species of Prunus thus far tested by artificial inoculations: *Prunus allegheniensis, P. americana, P. amygdalus, P. Andersonii, P. armeniaca, P. armeniaca,* var. *Mikado, P. avium, P. Besseyi, P. caroliniana, P. cerasifera, P. cerasifera,* var. *planteriensis, P. domestica,* different varieties, *P. eriogyna, P. glandulosa, P. hortulana, P. ilicifolia, P. integrifolia, P. Mume, P. Munsoniana, P. nigra, P. orthosepala, P. pennsylvanica, P. persica, P. platycarpa, P. pumila* (Linn.), *P. serotina, P. Simonii,* and *P. Watsoni.*

All the above hosts developed typical galls from artificial inoculations, except *P. pumila, P. ilicifolia* and *P. caroliniana.* These three hosts were inoculated both during 1913 and 1914 and have always showed negative results. *P. ilicifolia* and *P. caroliniana* were on their own roots and were not making very rapid growth at the time of the experiment, but it seems almost impossible that the host should not have been in a susceptible condition at some time during the period from May to September.

The sand cherry, *P. pumila,* was inoculated with cultures of *Bacterium tumefaciens* every week from June 20 to August 31, 1914. In all, eleven series of ten punctures each or a total of 110 stabs were made during this time without the development of a single gall at the close of the growing season. Further inoculations of *P. pumila* (thirteen series of ten punctures each or 130) made during 1915 on vigorous growing seedlings, gave negative results, agreeing with the work of the two previous years. The experiments thus far show this host to be entirely resistant. *P. Besseyi* also showed strong resistance.

German Prune, *P. domestica,* was inoculated with cultures of *Bacterium tumefaciens* in accordance with the general plan above. The first inocula-

[2] Phytopath. **3**: 59. 1913; California Agr. Exp. Sta. Bul. 235.

tions were made on May 3, 1914 and the last on August 31, 1914, in all 240 stabs being made. Twelve sets of experiments of ten punctures each were made in rapidly growing twigs of a seven-years-old tree, none of which were successful. Five cases of positive infections resulted from the inoculations on young trees two years from the nursery. The first ones from inoculations on June 29, the last from inoculations on August 24. The number of galls formed, ran as folows: 6, 6, 2, 2 and 8, and in size they ranged $\frac{1}{16}$ to $\frac{3}{16}$ of an inch in diameter.

TABLE I

Artificial inoculations on Italian Prune (Fellenberg) Prunus domestica. Concluded November, 1914

EXPERIMENT SERIAL NUMBER	DATE 1913	NUMBER OF INOCULATIONS	INFECTIONS	SIZE OF GALLS
				inches
211	May 10	5	0	
216	June 1	5	2	$\frac{4}{16}-\frac{1}{16}$
252	June 13	5	0	
264	June 16	5	0	
270	June 17	5	0	
282	July 14	15	5	$\frac{2}{16}-\frac{2}{16}-\frac{3}{16}-\frac{4}{16}-\frac{8}{16}$
292	July 15	5	0	
315	July 19	6	2	$\frac{2}{16}-\frac{4}{16}$
328	July 21	6	1	$\frac{2}{16}$
332	July 21	5	0	
343	July 22	5	0	
355	July 25	10	4	$\frac{1}{16}-\frac{3}{16}-\frac{2}{16}-\frac{1}{16}$
366	July 30	10	0	
259	June 9	5	0	
375	July 30	10	0	
390	August 9	10	0	
406	August 14	10	3	$\frac{2}{16}-\frac{1}{16}-\frac{1}{16}$
420	August 14	5	0	
		127	17	

A detailed account of the experiments on Italian (Fellenberg) prune, *P. domestica*, is given in Table I. Parallel inoculations with those given in this table were made on other hosts of Prunus, and the cultures were found to be in a virulent condition.

The condition of the inoculations tabulated in Table I on September 30, 1915, are here briefly summarized, the number referring to the same experiment as shown in Table I.

216. A single large gall has developed one foot from the surface of the soil. This gall extends about one-half the distance around the trunk of the tree and measures $3\frac{1}{2}$ inches in diameter.

282. These inoculations were made on three Italian (Fellenberg) prune scions grafted on apricot root. Four galls were found having a diameter of 2 to $3\frac{1}{2}$ inches. The infected branch measured $1\frac{1}{2}$ to 2 inches in diameter.

315. These inoculations show four galls varying considerably in size: one gall 2 inches in diameter (Plate VI, fig. 4); one gall $\frac{1}{2}$ inch in diameter (Plate VI, fig. 4); one gall $\frac{1}{8}$ inch in diameter; one very small gall that can only with difficulty be distinguished from the tissue.

It will be noted that two galls have appeared since the results were tabulated.

406. Two small galls not showing any increase in size over that indicated in tables.

The experiments for 1914 on this species (Table V) showed nearly the same percentage of positive inoculations. In general, many of the galls on resistant stock often fail to show further increase in size after the first year while others grow to considerable dimensions. The positive galls grow out more at right angles than do those on more susceptible stocks and do not so nearly surround the infected twig. Inoculations on resistant stock that fail to show gall formation the first season rarely ever do so later.

Data on the present condition of galls produced on German prune show a very similar condition to those on the Italian prune (Fellenberg) and will not here be repeated.

Myrobolan stock, *P. cerasifera,* was also thoroughly tested, trees from three different sources being used.

1. Vigorous growing twigs of a large six-years-old tree were inoculated one week apart by puncture from May 5 to August 31, 1914. There were fifteen series of ten punctures each, and from these 150 punctures, 150 galls developed, which varied in size from $\frac{1}{4}$ to $1\frac{1}{2}$ inches.

2. Inoculations made in vigorous growing sprouts of three-years-old roots gave nearly as good results as the above. On these, 120 inoculations were made in twelve series of ten stabs each. At the close of the growing season, 117 galls had developed.

3. The results from inoculations on a small myrobolan tree, the scions of which were secured from the Arnold Arboretum, showed much more resistance and are shown in Table II.

Prunus hortulana is regarded by many nurserymen as a good stock, especially for the native plums. Both seedlings and grafted trees have been tested. Thus far no marked resistance has been discovered, except with the variety known as Golden Beauty. The inoculation on this host for 1915, showed only 40 per cent infection. These inoculations were made in scions grown for the first season on peach stock. Vigorous growth of the inoculated twigs took place during the season, thus giving ideal

conditions for galls to develop. The inoculations of this host during 1914, showed much more resistance and are shown in Table III.

TABLE II

Artificial inoculations on Prunus cerasifera. Arnold Arboretum type. Concluded November, 1914

EXPERIMENT SERIAL NUMBER	DATE 1914	NUMBER OF INOCULATIONS	INFECTIONS	SIZE OF GALLS
				inches
595	June 20	10	10	$\frac{1}{4}-\frac{1}{2}$
646	June 29	10	8	$\frac{1}{16}-\frac{3}{16}$
709	July 6	10	9	$\frac{1}{16}-\frac{1}{8}$
776	July 13	10	8	$\frac{1}{16}-\frac{1}{4}$
822	July 20	10	5	$\frac{1}{16}$
902	July 27	10	8	$\frac{1}{8}-\frac{1}{4}$
963	August 3	Check	0	
A 41	August 10	10	4	$\frac{1}{4}-\frac{1}{8}$
A111	August 15	10	2	$\frac{1}{16}$
A149	August 17	10	4	$\frac{1}{16}$
A225	August 24	10	10	$\frac{1}{16}-\frac{1}{4}$
A253	August 31	10	2	$\frac{1}{16}$
		110	70	

TABLE III

Artificial inoculations on Golden Beauty. Prunus hortulana. Concluded November, 1914

EXPERIMENT SERIAL NUMBER	DATE 1914	NUMBER OF INOCULATIONS	INFECTIONS	SIZE OF GALLS
				inches
600	June 20	10	7	$\frac{1}{16}$
651	June 29	10	3	$\frac{1}{16}$
714	August 6	10	5	$\frac{1}{16}-\frac{1}{8}$
780	August 13	10	0	
826	August 20	10	4	$\frac{1}{16}$
906	August 27	10	1	$\frac{1}{16}$
967	September 3	Check	0	
A 11	September 4	10	3	$\frac{1}{8}$
A 44	September 10	10	0	
A114	September 15	10	1	$\frac{1}{16}$
A152	September 17	10	1	$\frac{1}{16}$
A250	September 29	10	0	
		110	25	

The two succeeding tables, IV and V, show considerable variation in results of the different hosts. There is, however, a reasonable degree of

consistency between the percentages of the different hosts for the two years during which the tests were made. The few seedlings of *P. pumila* that were inoculated during the year 1913, showed negative results, and *P. Besseyi*, the western sand plum, is strongly resistant. The next two hosts that should be considered are the German prune and the Italian (Fellenberg) prune. These belong to the group Domestica, a group containing many different varieties, some of which are being further tested for crown gall resistance. The two members of the group Domestica, referred to above, were the ones that have thus far shown the most marked resistance, but some of the other members of this group may be expected to have this characteristic. It is interesting to note that the German

TABLE IV

Summary of artificial inoculations on Prunus. Concluded October 3, 1913

SPECIES	VARIETY	NUMBER OF INOCULATIONS	INFECTIONS	PER CENT OF GALLS	SIZE OF GALLS
					inches
P. domestica	German Prune	75	2	$2\frac{2}{3}$	$\frac{1}{16}$–$\frac{1}{8}$
P. domestica	German Prune	50	5	10	$\frac{1}{10}$–$\frac{1}{4}$
P. domestica	Italian Prune	127	17	13	$\frac{1}{16}$–$\frac{1}{4}$
P. domestica	Reine Claude	17	4	23	$\frac{1}{16}$–$\frac{3}{8}$
P. insititia	Damson	138	51	37	$\frac{1}{4}$–$\frac{3}{4}$
P. domestica	Duane's Purple[1]	37	15	40	
P. persica	Elberta	61	57	93	$\frac{1}{2}$–$2\frac{1}{2}$
P. triflora × P. Simonii	Wickson (hybrid)	56	64	98	$\frac{1}{2}$–1
P. triflora	Burbank	31	31	100	$\frac{1}{4}$–$\frac{1}{2}$
P. cerasifera	Myrobolan	8	8	100	$\frac{1}{2}$–1

[1] A local commercial stock, propagated in California from sprouts, and belonging probably to the Damson type, as it is a small blue plum having the same flavor but differing in shape.

prune is described as being one of the plums longest under cultivation, and the oldest of the prune type. Seedlings came reasonably true, which might be important if it should ever come into general use as a stock. The Italian (Fellenberg) prune has a history of over a century, so is not a new plum. The resistance of these plants cannot in any way be regarded as due to slow growth, for the experiments were on rapidly growing scions or on growth stimulated by pruning of young trees.

The members of the Damson group appear to show considerable resistance, although the variety of *P. insititia*, known as *pendula*, is rather susceptible. Probably in this group, as in the group Domestica, considerable difference of resistance will be found.

The peach, *Prunus persica*, possibly should be tested somewhat farther,

TABLE V

Summary of inoculations made on Prunus. Concluded November 15, 1914

SPECIES	VARIETY AND SOURCE	NUMBER OF INOCULATIONS*	INFECTIONS	PERCENTAGE OF INFECTION	SIZE OF GALLS
					inches
P. pumila	2 varieties, Arnold Arboretum	110	0	0	
P. domestica	Italian Prune	140	10	7	$\frac{1}{16}$–$\frac{1}{8}$
P. cerasifera	P. Planteriensis	40	3	$7\frac{1}{2}$	$\frac{1}{16}$–$\frac{1}{8}$
P. domestica	German Prune	240	24	10	$\frac{1}{16}$–$\frac{3}{6}$
P. insititia	Damson	120	13	10	$\frac{1}{8}$–$\frac{1}{2}$
P. Besseyi		50	5	10	$\frac{1}{8}$–$\frac{1}{2}$
P. hortulana	Golden Beauty	110	25	22	$\frac{1}{16}$–$\frac{1}{8}$
P. Amygdalus†	Bitter Almond	100	22	25	$\frac{1}{8}$–$\frac{3}{8}$
P. domestica	Reine Claude	90	25	26	$\frac{1}{16}$–$\frac{1}{2}$
P. Armeniaca	Mikado	40	11	27	$\frac{1}{16}$–$\frac{3}{16}$
P. angustifolia	Watsoni	50	15	30	$\frac{1}{16}$–$\frac{1}{8}$
P. maritima	Arnold Arboretum	140	48	34	$\frac{1}{16}$–$\frac{1}{8}$
P. dasycarpa	Arnold Arboretum	130	55	42	$\frac{1}{16}$–$\frac{1}{2}$
P. Mitis	Arnold Arboretum	60	32	53	$\frac{1}{16}$–$\frac{1}{8}$
P. cerasifera	Arnold Arboretum	110	70	63	$\frac{1}{16}$–$\frac{1}{4}$
P. Munsoniana	Arnold Arboretum	70	48	68	$\frac{1}{8}$–$\frac{3}{16}$
P. Munsoniana	Arkansas	90	70	77	$\frac{1}{16}$–$\frac{3}{8}$
P. americana	Arnold Arboretum	100	83	83	$\frac{1}{16}$–$\frac{1}{2}$
P. hortulana	Arnold Arboretum	130	108	83	$\frac{1}{8}$–$\frac{3}{4}$
P. insititia	Pendula	90	77	85	$\frac{1}{16}$–$\frac{3}{4}$
P. davidiana		110	96	88	$\frac{1}{8}$–$\frac{3}{4}$
Schinus Molle	Pepper tree	110	97	88	$\frac{1}{4}$–$1\frac{1}{2}$
P. triflora	Burbank	120	109	90	$\frac{1}{2}$–$1\frac{1}{2}$
P. nigra	Arnold Arboretum	60	56	90	$\frac{1}{4}$–$\frac{3}{8}$
P. orthosepala	Arnold Arboretum	80	72	90	$\frac{1}{16}$–$\frac{1}{8}$
P. Mume	Arnold Arboretum	100	91	91	$\frac{1}{4}$–$\frac{1}{2}$
P. Munsoniana	Pits Arnold "	140	130	92	$\frac{1}{16}$–$1\frac{1}{2}$
P. cerasifera	P. divaricata	100	94	94	$\frac{1}{8}$–$\frac{3}{4}$
P. persica	Elberta	130	122	94	$\frac{1}{4}$–$\frac{3}{4}$
P. armenica	Royal Apricot	120	117	97	$\frac{1}{4}$–1
P. triflora	Arnold Arboretum	140	137	97	$\frac{1}{8}$–$\frac{3}{4}$
P. Munsoniana	El Paso	100	97	97	$\frac{1}{4}$–$\frac{1}{2}$
P. cerasifera	Sprouts	120	117	97	$\frac{1}{4}$–$1\frac{1}{2}$
P. triflora × P. Simonii	Wickson (hybrid)	140	138	98	$\frac{1}{8}$–$\frac{3}{4}$
P. cerasifera	Tree	150	150	100	$\frac{1}{4}$–$1\frac{1}{2}$
P. monticola	Arizona Experiment Station	40	40	100	$\frac{1}{2}$–$1\frac{1}{2}$
P. Simonii	Arnold Arboretum	130	130	100	$\frac{1}{4}$–$1\frac{1}{2}$

* The number of inoculations divided by ten is the number of separate experiments made with the various hosts.

† *Prunus Amygdalus* was not growing well during the last part of the season and no infections showed after that of July 6. Before this time a large percentage of the inoculations were positive. This will be repeated another year.

although the several varieties as Elberta, Saucer or Peento, Salway, Lovell and Muir seedlings, did not show resistance.

Fourteen different varieties of almond seedlings growing at the University Farm at Davis, California, were inoculated in 1913, and in all cases developed a high percentage of galls. So far, none of the almonds or peaches have shown marked resistance.

Prunus cerasifera, var. *Planteriensis*, Table V, is described as a double-flowering shrub and its resistance should again be confirmed. The trees from the Arnold Arboretum are on peach roots and show a more shrub-like growth than does the larger imported French tree. The slower growth may in some degree account for the smaller percentage of successful inoculations, although the general growth and characteristics of the Arnold Arboretum tree would suggest that it is probably much nearer to the wild type.

Prunus hortulana, variety Golden Beauty, Table III, is the most resistant of this species thus far tested. It is of interest to remember that this variety is supposed to have originated in western Texas, which is far outside of the limits usually given for this genus.

Of the resistant species of Prunus thus far observed, *Prunus pumila* and the two varieties of *P. domestica*, German prune and Italian (Fellenberg) prune, are the most promising. *Prunus pumila* is a shrub and while easy to grow from pits or cuttings, would be likely to dwarf the varieties of stone fruits grafted upon it. The two varieties of *P. domestica* named above, should be well adapted for other varieties of this genus, and possibly some of the Japanese types of plums. Domestica stock is used to a limited extent by some nurserymen in California and apparently has given satisfactory trees. In this instance the stock was grown from sprouts which would give a root likely to produce suckers.

The apricot is commonly used in California as a rootstock, especially for apricots. Pits of the Royal variety being easily obtained are for the most part planted. The following four species have been tested: *P. armeniaca*, different varieties, *P. armeniaca* var. *mikado*, *P. mume*, *P. mandschurica*. The tests of these species can be readily compared in Table V, with the exception of *P. mandschurica*, which was tested during 1915 for the first time. Ten puncture inoculations were made on this host at three different dates. At the close of the growing season, no galls of large size have developed, although the grafts have grown 4 to 5 feet in length. The positive infections are 60 per cent and show as small points or knobs about $\frac{1}{16}$ of an inch in diameter. This size is in marked contrast with the large galls that usually develop on apricot from artificial inoculation. Ten different commercial varieties of California apricots belonging to *P. armeniaca*, were given a preliminary inoculation test during 1915 and showed

65 to 95 per cent infection. *P. armeniaca* var. *mikado* for 1915 showed only 22 per cent successful inoculations, the galls formed being $\frac{1}{16}$ to $\frac{1}{8}$ inch in diameter.

The Damsons, *P. americana* and *P. hortulana*, have never been used to any extent in California, although more popular in other sections of the country. *P. americana* and *P. hortulana* would be well adapted for native species of plums which are not much grown in California.

It will be noted that our most popular stock, Myrobolan, peach, apricot and almond, are very susceptible to crown gall. These data, however, only go to confirm field observations, that all the different stocks used for stone fruit are often badly infested with the disease.

From the work thus far done, no definite recommendations can be made as to the use of resistant stock, although seedlings of German prune and the Italian (Fellenberg) prune should be well adapted as a stock for members of the group Domestica.

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EXPLANATION OF PLATE VI

FIG. 1. Represents galls produced artificially on a resistant stock, German prune, *Prunus domestica*. Inoculated June 29, 1914. Photograph made June, 1915.

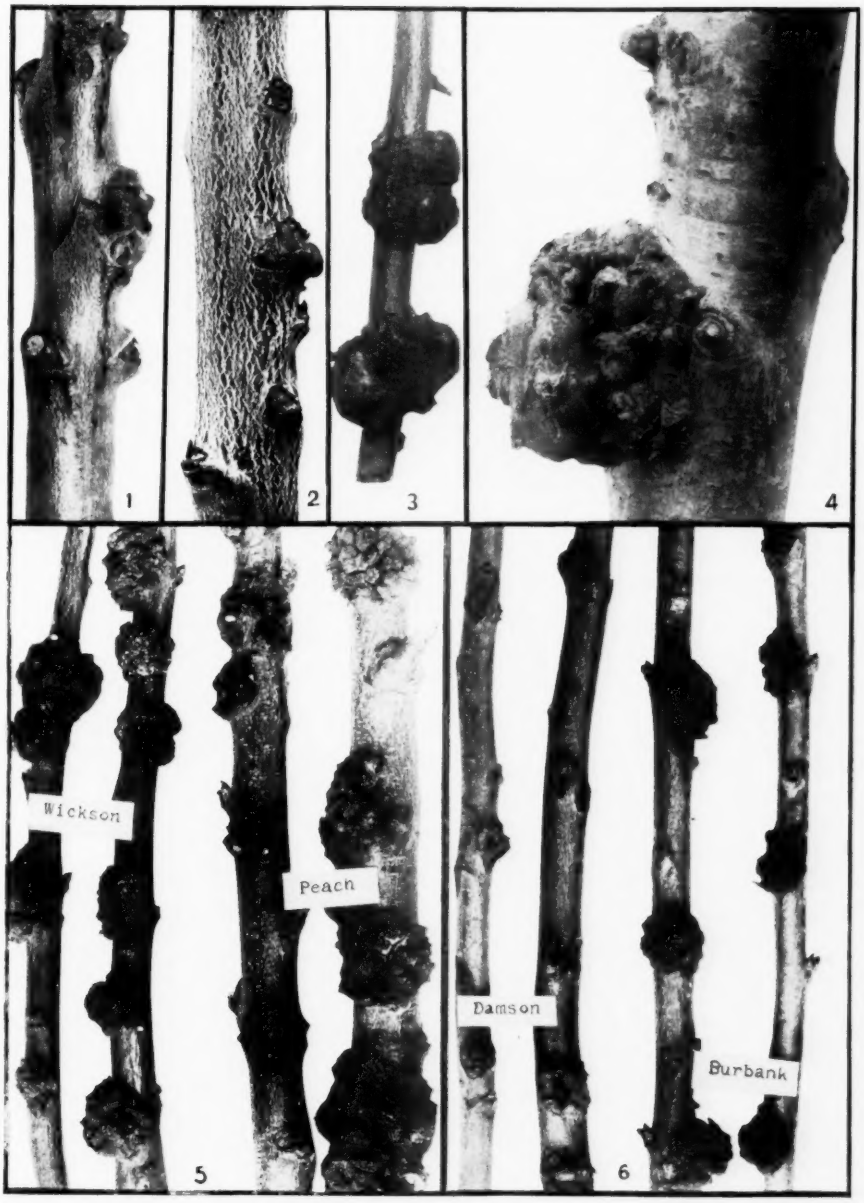
FIG. 2. Shows artificial galls on Italian prune (Fellenberg), *Prunus domestica*. Inoculated July 25, 1913. Photograph made December, 1913. Figures 4, 5 and 6 show galls on other hosts made at the same time with same culture as part of same experiment.

FIG. 3. Myrobolan plum, *Prunus cerasifera*. Inoculated July 13, 1914. Photograph made September 15, 1915. Shows rapidity of gall growth on susceptible stock.

FIG. 4. Same experiment as is illustrated in figure 2, and probably the same galls as are there figured. Photographs made September, 1915, to show manner in which galls usually develop on resistant stock. Note that they are growing out almost at right angles to host, without surrounding the branch to any great extent. A comparison of figures 2 and 4, will also show the rapidity of growth of this stock during the time of the experiment.

FIG. 5. Elberta peach, *P. persica*, and Wickson plum, hybrid of *P. Simonii* and *P. triflora*. Same experiment as is shown in figures 2, 4 and 6. Illustrates two susceptible varieties and the relative size of gall as compared with the others of this experiment.

FIG. 6. Damson plum, *P. insititia*, and Burbank plum, *P. triflora*, to show relative size of galls as compared with those in figures 2, 4 and 5. Note galls on Damson stock are smaller and in some cases have not developed. This stock is resistant.



SMITH: RESISTANCE TO CROWN GALL

REVIEWS

Materialy po Mikologii i Fitopatologii Rossii. God. I, No. 1–3. Petrograd, 1915. Redactor A. A. Jaczewski. Izd. Depart. Zemled. (Journal of Mycology and Phytopathology of Russia, Vol. I, Nos. 1–3, Petrograd, 1915. Edited by A. A. Jaczewski. Published by the Department of Agriculture.)

Russian workers in the field of plant diseases may be congratulated upon the birth of a new periodical devoted to purely mycological and pathological matters. The need for such a journal has been felt very deeply in Russia in the last few years, as the result of a rapid growth of research along these lines, especially since the establishment of the Provincial Agricultural Experiment Stations in 1913. The first three numbers of "Materialy" already have been distributed and contain original articles, reviews, notes and chronicle. It is also the aim of the editor to include later on such of the Bureau correspondence as may be of general interest to all readers.

The necessity of a thorough mycological survey of various districts of the Empire, as an indispensable condition of success in the work of plant protection, is fully recognized. Results of such surveys are published in every number of "Materialy." Along with fungi of a more or less general occurrence a number of new species have been reported. Some of these appear to be of considerable interest and economic importance. It will suffice to mention *Uromyces alhaginis* and *Septoria alhaginis* from *Alhagi camelorum* (No. 1), *Pyrenochaeta elodeae* from *Elodea densa* (No. 2), a new species of Helminthosporium discovered by Jaczewski growing in the laboratory upon a mud cone of a locust (No. 2), *Rhodosticta onobrychidis* from esparcet (No. 3), *Cercosporella lini* from *Linum nervosum* (No. 3), *Exobasidium Citri* from young fruits of mandarin (No. 3).

According to the reports of the editor, the personnel of the Bureau is very actively engaged in research work on plant diseases. Certain definite conclusions have been reached regarding control measures for clubroot of cabbage and American gooseberry mildew, as well as the cause and prevention of a peculiar disease of grains known as "drunk bread," possibly due to species of Fusarium. Results of testing various fungicides are much in favor of lime-sulphur compounds as substitutes for bordeaux and other copper-salts mixtures. Work on fungous diseases of insects, on rust-resistant varieties of grains, and on certain other problems is still under way.

The Bureau has a considerable number of pure cultures and duplicate herbarium specimens, including those described by Russian scientists as new species, and they are offered for exchange with other institutions. Partial lists of these cultures and specimens are given in Nos. 1 and 2, and the additional ones will appear in subsequent numbers of the Journal.

The chronicle gives an account of various events related to phytopathology in Russia, such as notable publications, meetings, etc.

Reviews are divided in two sections: one deals with Russian literature; the other, with foreign publications.

The editorial of the first number contains a statement that this new journal "will be sent free, on an exchange basis, to all mycological laboratories and to the Russian specialists." The importance of closer international relations in phytopathology is now fully recognized, and it is hoped that the respective American institutions will accept the above offer of the Bureau of Mycology of Russia—the country which, to a large extent, has been "terra incognita" for many foreigners.

MICHAEL SHAPOVALOV

The Journal of Plant Protection (Byôchû-gai Zasshi). Published by the Nippon Plant Protection Society. (Nippon Shokubutsu Aigo-kwai.)

The importance of a knowledge of plant pathology and applied entomology for farmers and amateur plant growers, in order to avoid the damage caused by fungi and insects, was gradually recognized among the educated class of Japanese people especially interested in plants, who at last assembled together and organized a society for the purpose of explaining the importance of "plant protection" to the people of Japan and to increase special knowledge concerning the enemies of plants among themselves.

The society was founded in Tôkyô at the beginning of 1914, by 66 members, most of them belonging to the higher ranks of professional and amateur horticulturists, including Count Ôkuma and many others, with the cooperation of the government pathologists of the Plant Quarantine Station as well as the Central Agricultural Experiment Station. The business is actually carried on by eleven specialists, whose principal work is to visit the houses of full members, at least once a month, to inspect for diseases and to give any advice about the care of the plants, whether planted in gardens or in pots in dwarf form.

The present journal began publication in October, 1914, and now appears as a monthly publication, of regular octavo size, comprising about ninety to one hundred pages in each number, with photographic plates and illustrations in the text. The contents are commonly classified into

five or more groups, such as original articles, reviews of foreign papers, summaries of the results of pathological and entomological experiments conducted by central or provincial agricultural experiment stations of Japan, miscellaneous information, questions and answers, and the reports of the Society matters, and so forth. Most of the original articles seem to have been written in rather a popular style and not in a strictly scientific manner. Still, in some cases, new fungi or bacteria are described in detail. The following are some of the more important phytopathological papers that have appeared in this Journal up to the end of 1915:

(1) BOKURA, U. On the bacteriosis of the mulberry tree. Vol. 1 (1914), pp. 29–31; 149–154.

(2) FUZIKURO, Y. Important diseases of ornamental plants in Formosa. Vol. 2 (1915), pp. 321–323; 406–409.

(3) HARA, K. On the diseases of certain plants caused by parasitic fungi belonging to the Coccoideaceae. Vol. 1 (1914), pp. 44–48; 267–270; Vol. 2 (1915), pp. 324–328.

(4) HARA, K. A new disease of rice. (Sclerotinia phyllacoloides Hara sp. nov.) Vol. 2 (1915), pp. 948–949.

(5) HORI, S. A serious disease of tea caused by a new bacterium, Bacillus Theae Hori and Bokura sp. nov. Vol. 1 (1914), pp. 247–252; Vol. 2 (1915), pp. 1–7.

(6) HORI, S. Contributions to the study of plant diseases. Vol. 2 (1915), pp. 662–666; 745–748; 833–836; 927–932; 1015–1017 (so far as issued).

(7) ISHIYAMA, S. On black spot disease of Japanese plum fruit caused by Pseudomonas pruni Sm. Vol. 1 (1914), pp. 48–51; 166–171.

(8) NAKATA, K. Brown rot of sugar beet in Korea with especial reference to the fungus Cercospora beticola Sacc. Vol. 2 (1915), pp. 116–122; 207–210.

(9) NAKATA, K. On the fungus causing the anthracnose of cotton. Vol. 2 (1915), pp. 309–311.

(10) TAKIMOTO, S. A preliminary report on the sclerotiosis of ginseng. Vol. 2 (1915), pp. 328–331; 422–426; 521–523.

(11) TAKIMOTO, S. "Leaf burn" disease of Vicia Faba and a new bacterium, Pseudomonas Viciae Uyeda n. sp. as the cause of the disease. Vol. 2 (1915), pp. 846–851.

(12) TSURUDA, S. Some newly found diseases of barley and wheat in the Province of Shidzuoka. Vol. 2 (1915), pp. 854–859.

(13) TSURUDA, S. On a new fungus, Phyllosticta Broussonetiae Hori n. sp., of Japanese paper mulberry. Vol. 2 (1915), pp. 1040–1042.

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PHYTOPATHOLOGICAL NOTES

Marking laboratory apparatus. It often becomes necessary to mark laboratory apparatus for purposes of identification. In many cases metal apparatus is seriously damaged if a hardened steel die and hammer are used. Various methods are in common use for marking such apparatus. Those which have proved the most satisfactory for our purposes in the laboratory of Forest Pathology, U. S. Department of Agriculture, Providence, R. I., are indicated below.

Iron and *steel* (not nickel-plated) can be marked by the well-known copper-sulphate method. In practice we have used a pointed toothpick and a watery solution of copper sulphate. The marker is prepared for use by thrusting one end of a wooden toothpick into the small end of a cork which fits a small vial. The other end of the toothpick is pointed, while around it just back of the point a small amount of absorbent cotton is wrapped. In the vial is placed a sufficient quantity of copper-sulphate solution to wet the cotton when the cork is in place. The marking is done by removing the cork with the attached toothpick and tracing the required letters or numbers on the steel or iron with the wet point of the toothpick, in much the manner that a pen would be used for a similar purpose. The surface to be marked previously must have been freshly cleaned (e.g., with fine emery cloth). The cotton merely serves to lift a greater quantity of the copper solution than would be possible without it. The mark will appear as a deposit of copper, which can be intensified by a second or third application.

Glassware is permanently etched by the well-known hydrofluoric acid method. In practice we keep a small dish of melted paraffin in the water-bath and in this a small swab made of absorbent cotton or cheesecloth wrapped about one end of a small rod of wood. With the swab a thin film of paraffin is quickly smeared over the surface of the cold glass at the point where it is to be marked. This film instantly hardens. Through this, to the glass, the required legend is scratched with a dull needle or sharply-pointed pencil, and hydrofluoric acid from the rubber or wax covered bottle applied with another swab of cotton similar to the one mentioned above, taking care that the acid does not come in contact with the fingers. An application of a few minutes is usually sufficient and the acid can then be washed off with water. If the glassware will stand a stream of hot water, this will be the most convenient method of quickly and cleanly

removing the paraffin; otherwise it may be partially removed by scraping, and finally cleaned with a piece of cloth wet with any one of the well-known solvents of paraffin. In the quiet air of a laboratory it often happens that the heavy acid fumes slowly spread beyond the area of paraffin and cause a fogging of the glass. This is overcome by setting the apparatus in a draught of air during the time the acid is acting, or better by covering a much larger area of glass with paraffin at the outset.

Nickel plated articles, as well as iron, steel, brass, bronze, copper, German silver, and zinc, are very neatly etched in precisely the same manner as glassware, except that strong nitric acid is used instead of hydrofluoric. Care should be taken that the acid does not come in contact with the skin, and that the fumes are not inhaled.

J. FRANKLIN COLLINS

Marking trees in the field. When working in the field it is often necessary to mark trees for future positive identification, in order that successive observations may be made on the same trees. For this purpose various methods are in use by various workers.

The writer has used many different methods, of which the following have proved the most satisfactory. If it is necessary that the mark remain visible for a few months only, and the bark is not too rough, we generally use "Dixon's Yellow Lumber Crayon," and occasionally also the red or white crayons when a distinctive color is desired for special purposes. These crayons are of a waxy nature and a mark made with one of them usually lasts for some months. We have often marked trees with these crayons in August or September and the legend or number has been clearly visible the following spring.

If a more permanent and conspicuous mark is desired, white paint and a brush will be found more serviceable when many trees are to be marked. If only an occasional tree is to be marked in this manner, a more convenient method (and one which makes it unnecessary to carry a paint-pot about) is to take in the pocket a small tube of artist's oil paint of the color desired. When this is to be used the cap of the tube is unscrewed and the tube held perpendicular to and against the surface of the bark or wood. By moving the tube over the surface of the bark, and at the same time gently pinching the tube, any desired symbol or number can be painted on its surface, no brush being necessary. A very little practice will enable one to make a neat symbol that will usually last from two to five years under ordinary conditions.

Occasionally it is desirable to mark a tree in an inconspicuous yet definite manner. For this purpose we have for years successfully used long copper tacks with heads about one-quarter inch broad, upon which dis-

tinctive numbers have been stamped with steel dies. By beginning with No. 1 in each new locality it is rarely necessary to use more than two figures on a tack. In practice the tacks are usually placed at a certain uniform height on each tree and the height and orientation of each recorded. This makes it comparatively easy to find the tack at a later date. In the course of two or three years the tack may become entirely overgrown by the newly formed bark and wood. If the position on the tree has been carefully recorded, it is not a difficult matter to find the small depression which indicates the position of the tack, and a little cutting with a knife will reveal the number. When a tree is susceptible to a specially virulent parasitic disease (e.g., the chestnut bark disease), or when for other reasons it becomes necessary to take extra precautions against infection at the point where the tack would be driven into the tree, some other method may have to be used.

J. FRANKLIN COLLINS

Cutting and trimming small blocks of wood. For cutting small pieces of wood, twigs, and so forth, into still smaller blocks preparatory to embedding, preserving, or dehydrating, or for any other purpose where it is necessary to have the material trimmed or cut without crushing any of the tissues adjoining the cut, we have found no instrument superior to the fine-toothed fret-saw. To many people this saw may be better known as a bracket-, scroll-, jig-, or puzzle-saw, and is almost universally used to make perforated brackets and zig-zag puzzles. The foot power saw is undoubtedly the best for many purposes, although personally we have rarely used it, as we prefer to use the hand saw of the type used by jewelers in sawing out intricate designs in sheet metal.

When the hand fret-saw is used it will require a little practice to hold the material sufficiently rigid to saw it easily and prevent breaking the saw. This difficulty is largely overcome by using a supporting strip of soft wood, seven-eighths of an inch thick by two or three inches wide, and six or eight inches long, one end of which is screwed or clamped firmly to a table or bench. The other end projects beyond the edge of the table for three or four inches. The under side of this strip of wood is beveled backward for a distance of two inches so that the projecting end of the strip is not over one-eighth of an inch thick.

When small blocks, or those specially difficult to hold, are being cut, the operation is generally simplified by holding the block endwise between the thumb and first finger and pressing it down firmly on top of the beveled strip of soft wood (at the thin edge), and at the same time sawing into the edge of the soft wood a sufficient distance to cut through the block without moving the latter.

In using the hand-type of saw it is usually best to hold it nearly vertical, with the handle below the support or bench. The saw should be fastened into the saw-frame so that the cut will be made on the downward stroke.

J. FRANKLIN COLLINS

Polishing sections of wood. Blocks or cross-sections of healthy or decayed wood which are to be used for exhibition purposes or for photographing can readily be smoothed and polished in such manner as to show the grain very clearly by the following method. A fine-toothed hand-saw (or even a circular saw) of the usual type is used to cut the wood at the points desired. The surface to be polished is then held against a flat, rapidly rotating, sandpaper disk. The disk used by cabinet-makers is often made of wood with the sandpaper glued to its surface.

For my own use I have had constructed a flat-faced, circular, iron disk, nine inches in diameter, which gives a much finer grade of polished surface than the wooden disk. The sandpaper is cut into nine-inch squares. The projecting corners are turned back over the edge of the disk and there held firmly in place by heavy spring clips. This arrangement allows the sheet of sandpaper to be easily and quickly removed and a finer or coarser grade substituted whenever desired. The disk is placed on the shaft of an ordinary turning-lathe, but could easily be adapted to be attached to almost any type of motor.

The final polishing is done with the finer grades of sandpaper. For best results the block of wood must not be held against the rapidly rotating disk sufficiently long at any one time to cause scorching and consequent discoloration of the wood.

J. FRANKLIN COLLINS

Sclerotium Rolfsii in Illinois. During the summer of 1915 a number of the prostrate plants in the perennial garden of the Floricultural Division of the University of Illinois were found dying from a crown-rot. A study of the diseased material showed that the rot was caused by *Sclerotium Rolfsii* Sacc. This is the first report of the occurrence of this fungus in Illinois and the first account of this fungus causing a serious disease of the cultivated perennials.

The symptoms of this disease are similar to those described by Rolfs and others in the South. In all plants examined the fungus produced a typical crown-rot, and in many cases where the leaves and branches touched the soil, a rotting of these parts ensued.

The fungus is characterized by a white, rather straight, mycelium, which spreads out in strands on the under side of the plant, in a fan-shaped

or radial manner. On the surface of this mycelium large numbers of smooth and usually spherical sclerotia, which are at first white, yellow, and finally dark brown, develop. The sclerotia resemble radish or mustard seeds. From the size of the sclerotia in the field and those obtained in culture, it appears that they are somewhat larger than the sclerotia found in the South. Saccardo, in describing the species, gives 0.5 to 0.8 mm. for the diameter of the sclerotia, while Smith reports the following measurements, 0.8 to 0.9 by 1.2 to 1.3 mm. The sclerotia found in the perennial garden measure 0.8 to 3 mm. in diameter, while those on potato plugs may reach a diameter of 5 mm.

The disease first appeared in July and a number of plants were killed during the warmer weather. However, it persisted until the last of October, although its attacks were less severe, only a few branches of the plants being killed. The disease appeared in various parts of the garden and its spread from plant to plant could be clearly followed.

The writer has found the fungus growing on and killing the following perennials: *Campanula medium*, *C. persicifolia*, *C. carpatica*, *C. nobilis*, *Erigeron glabellus*, *Dianthus plumarius*, *Dracocephalum arganese*, *Penstemon pubescens*, *P. murrayanus*, *Phlox subulata*, and *Eupatorium ageratoides*. Of these plants, the Campanulas appear to be the most susceptible, the species *C. medium* being particularly so.

The severity of the disease was, no doubt, influenced by the extremely wet summer, when 29 inches of rain fell between March 1 and October 1, 1915. During the month of July, when the disease was at its height, the rainfall was 7.3 inches. The temperature which prevailed during the summer was rather low as compared with that of the two previous summers. July was the warmest month, with an average temperature of 74° F. It appears that at least two factors are necessary for the growth of this fungus, an abundance of moisture and a soil temperature above 60° F.

GEO. L. PELTIER

A note on Cronartium pyriforme. In looking over the literature on the aecial stage of *Cronartium pyriforme* (Peck) Hedgc. and Long on pines, I can find few definite data in regard to the size of the trees infected or the height at which infections occur. Orton and Adams[1] in reporting *Cronartium* (*Peridermium*) *pyriforme* on *Pinus pungens* state, "One of the striking features of this rust was that in every case but one, of a dozen or more which were seen, the infection was upon the trunks of the young trees

[1]Orton, C. R., and Adams, J. F. Notes on Peridermium from Pennsylvania. Phytopath. **4**: 23–26. 1914.

very close to the ground. In the one exception it was upon the lowest branch but not more than 6 inches above the ground." Hedgcock[2] reports the occurrence of the parasite only on small saplings of *Pinus pungens* and *Pinus ponderosa*. Hedgcock and Long[3] give the area of infection as varying from an inch to more than one foot in length on young lodgepole pines and western yellow pines. My former observations[4] on this rust on *Pinus ponderosa* show the largest infected tree to have a diameter of 8 inches at breast height. On another tree the infection occurred 5 feet from the ground. The areas of infection, varying from 2 inches to a foot in length, were usually found on the main stem but occasionally on the branches.

In the spring of 1915 a specimen of this rust on *Pinus ponderosa* presenting some unusual features was sent to the laboratory of Forest Pathology, U. S. Department of Agriculture, San Francisco, Calif., from a forest in the Coast Range of California. According to information from the field, the infection began at a height of 35 feet from the base of the tree, extending up the trunk for a distance of 3 feet, including a branch whorl and running into the base of the limbs. The entire top of the tree above the place of infection was dead, as were also the infected limbs of the branch whorl. The tree was about forty years old at stump height and had a diameter of 14 inches at breast height.

Upon examination of the specimen, which included the infected area on the trunk and the branch whorl, the tree trunk at the base of the infection was found to have a diameter of $7\frac{1}{2}$ inches and to show 14 annual rings. A very slight spindle-shaped swelling had extended over the entire area of infection. The aecia were sporulating abundantly, both on the trunk and branches. The color of the spore powder, three days after collection, was a very slight degree lighter than Cadmium Orange.[5]

The thickness of the dead bark under which the aecial sori developed was remarkable. One sorus, 5 mm. wide by 1.5 mm. deep, was completely covered by a bark scale 6 mm. thick. A second one was found well covered by a bark scale 7 mm. thick.

The specimen was collected in Trinity County, California, at an elevation of 2200 feet.

J. S. BOYCE

[2] Hedgcock, George G., and Long, William H. A disease of pines caused by Cronartium pyriforme. U. S. Dept. Agr. Bul. 247: 14. 1915.

[3] Loc. cit., p. 13.

[4] Quoted by Hedgcock and Long. Loc. cit., pp. 14 and 15.

[5] Ridgway, Robert. Color standards and color nomenclature, Plate III.

Pan-American Scientific Congress. The following resolution in regard to plant protection was adopted by the Congress at its final session in Washington, January 8, 1916:

"XIII. That an American plant-protection conference be convened, the delegates thereof to be one or more technical experts from each of the several American countries, and that as soon as practicable a meeting of this conference be held to discuss suitable legislation, the means of establishing competent scientific bureaus, and to recommend such cooperative research work and control of plant introduction as may be advisable, and to use all reasonable efforts to secure appropriate action by the several countries."

A committee, consisting of C. L. Marlatt, D. G. Fairchild, and C. L. Shear, of Washington, D. C.; John R. Johnston, of Cuba; C. D. Andrade, of Ecuador; E. Carasco, of Chile; and Roberto Sundberg, of Uraguay, was appointed by the Chairman of Section III as a temporary committee to assist in promoting the purposes of the resolution.

Kew Pathological Laboratory. A laboratory for the exclusive investigation of problems in plant pathology has been equipped at the Royal Botanic Gardens, Kew, England, and work is now in progress. The laboratory has been formed by the alteration of two Georgian cottages facing Kew Green. Mr. A. D. Cotton, formerly of the Cryptogamic Herbarium at Kew is assistant, first-class, in the plant pathology laboratory and is now in active charge of the work. He will devote his entire time to plant pathology. William Broadhurst Brierley, M.Sc., of the University of Manchester, has also been appointed a first-class assistant in the laboratory.

Recovery of a chestnut tree from a lightning stroke. Lightning injury to trees of various species is a matter of common observation. Sometimes trees are killed outright without being shattered or externally wounded. More often, however, the stroke causes a more or less severe shattering of the tissues, which may be accompanied by the death of the tree or by no apparent injury beyond the wound itself. In many cases neither death nor important mechanical injury results.

An instance of lightning injury to a chestnut tree, *Castanea dentata*, which differs in some respects from any recorded in available literature and seems of sufficient interest to warrant publication, has recently come under the writer's observation. The chestnut referred to is situated about one mile above Van Bibber, Maryland, on the south side of the Baltimore & Ohio track and not far from the railroad's right of way, a short distance below Bush River station. The tree has two trunks of nearly equal size

(14 to 16 inches, diameter, breast high) joined for only a few inches above the surface of the ground. One trunk slants slightly to the south, the other to the north.

This tree was first seen by the writer April 28, 1914, and at once attracted attention, because both halves retained apparently all the burs of the previous season's crop. Single branches or small trees killed by the chestnut blight when the nuts are partly mature characteristically retain their burs as well as leaves for a year or more; in fact, this has come to be regarded as a "signal" of the possible presence of the disease. The writer had never before seen a large chestnut with burs on all its branches and it seemed as if the tree must have been girdled near its base so quickly as to kill both trunks during a single season.

Examination showed, however, that the tree had been struck by lightning. The southern trunk bore on the side farthest from the north trunk a characteristic lightning groove from two to four inches wide which reached nearly the length of the tree. The north trunk showed no scar whatever but had apparently been killed by the shock. Neither trunk showed any evidence of infection with *Endothia parasitica*. Under date of April 28, 1914, the writer made the following entry in his field notebook, "A large double chestnut struck by lightning holding burs as though diseased [by *Endothia parasitica*]." During the summer of 1914 the locality was visited about once a month in connection with other work on the chestnut; beginning with July 6, the tree was used as a marker for locating inoculations and on this date the following directions were entered on the notebook, "Follow up track to third cut, cross fence by dead tree with burs." August 10, 1914, the tree appears on the sketch map labeled "Double dead chestnut with burs." October 6, 1914, it appears on the sketch map as "Double lightning-killed tree." The tree was also observed on May 31 and December 30, 1914. About the middle of the summer numerous water-sprouts appeared at the base of the tree on the northwest side. This was the only indication that the tree had not been killed outright. On May 14, 1915, no change was noted except that a few of the burs had fallen.

The locality was not visited again until October 7, 1915, when the northern half, the one which had not been scarred by the lightning, was found to be in apparently full foliage and to have a few nearly mature burs. The half which had been actually struck by lightning, that is, bore the lightning scar, was quite dead and not only the dead burs but small branches were falling. The northern half showed several branches affected with the chestnut blight. Two branches had apparently been girdled early in the summer before the leaves had attained full size, as they still bore the partly developed leaves.

If the data presented above are correct, and in view of the frequency with which the locality was visited and the notes made, this seems certain, the tree was struck by lightning late in the summer of 1913, that is, when the burs were practically full size. It showed no signs of growth except the small water-sprouts at the base of the tree until the spring of 1915. At this time the buds formed more than eighteen months earlier developed on the unscarred half of the tree.

Two explanations of this peculiar phenomenon have been suggested to the writer. One is that the failure of the north half to leaf out in 1914 was due to the killing of its root hairs and small roots by the current passing through the ground, and that the buds and the cambium layers of the larger roots and trunk although uninjured did not begin growth until the root hairs had been regenerated in sufficient number to furnish them with water, that is, not until the spring of 1915. The failure of the tree to regenerate root hairs and to leaf out late in the summer of 1914 might readily be explained by the extreme drought of that season.

A quite different explanation is that the tree suffered from a severe shock, or partial electrolysis of the protoplasm, which permitted some activity during 1914, sufficient for the formation of water-sprouts, but, in conjunction with the severe drought, not sufficient for the development of the buds. While it is impossible to demonstrate which, if either, of these hypotheses is correct, they are suggestive explanations of the known facts.

NEIL E. STEVENS

Sulfur paste as a spray for peaches. The unusual losses in 1915 sustained by peach growers in many sections on account of brown rot (caused by *Sclerotinia cinerea*) and of scab (caused by *Cladosporium carpophilum*) have stimulated much inquiry in the agricultural press and in fruit growers meetings about summer spraying to prevent these diseases. At a recent meeting of the Western New York Horticultural Society, a grower of peaches commended to fellow growers the use of a sulfur paste instead of the Scott lime-sulfur mixture. His claim was that the paste was more easily prepared than the Scott mixture and that it could be used up until the day of picking without serious objection from spotting the fruit.

The writer has had considerable experience in preparing the paste and can vouch for the ease of preparation and for the excellent manner in which the suspension passes through a spraying machine.

A description of the preparation[1] of the paste has been published by Reddick and Crosby[2] but as this was incidental to an experiment with apples, repetition seems desirable. Arsenate of lead may be used or omitted as desired.

The exact method of preparation as used in this experiment is as follows: 2½ ounces of pulverized glue was dissolved in 2½ to 3 gallons of warm water; 20 pounds of the finely ground sulfur and 2 pounds of powdered arsenate of lead were weighed out into a large pail or other convenient receptacle. Glue solution was added as required, and was worked into the mixture by kneading with the hands. This required about five minutes. After the mixture was thoroughly wetted, it was thinned about one-half with water and poured into the strainer of the spray tank. The strainer consisted of a wooden box with a bottom of copper gauze, 20 meshes to the inch, supported by heavier galvanized gauze, 4 meshes to the inch. By turning the flow of water from the filling apparatus into the mixture, it was easily worked through the gauze with the hands or a brush.

DONALD REDDICK

Personals. Dr. J. J. Taubenhaus, associate plant pathologist of the Delaware Agricultural Experiment Station, recently accepted the position of head plant pathologist and physiologist of the Texas Agricultural Experiment Station. His new address after February 20 will be College Station, Texas. Prof. F. H. Blodgett, the former incumbent, is to engage in extension work in plant pathology.

Mr. George Massee has retired from the Cryptogamic Herbarium at Kew and Miss Elsie M. Wakefield is now in charge.

Dr. L. O. Kunkel, of the Bureau of Plant Industry, who is abroad for a year under a traveling fellowship from Columbia University, is located for the winter with Dr. Friedrich Oltmanns, at Freiburg in Breisgau, Germany.

Dr. H. W. Wollenweber continues work on his Fusarium Monograph at the Kaiserliche Biologische Anstalt, Dahlem-Berlin.

Notice. Attention is called to the action of the Society at the Columbus meeting in directing the publishers and the Business Manager to raise the price of back volumes of PHYTOPATHOLOGY on July first from $4 to $5 per volume. Separate copies will not be sold except in cases where the volumes are already broken, and the price of such copies will be 85 cents each.

[1] This method of wetting sulfur has been known to sulfur chemists for many years.

[2] Cornell Univ. Agr. Exp. Sta. Bul. 354: 82. 1915.

Notice. The fifty subscribers necessary to undertake the publication of the card index to Pan-American phytopathological literature have not yet been secured. As it is desirable to make arrangements for the publication of the cards as soon as practicable, we beg to urge that each member of the Society who is connected with an institution supporting a library make a special effort to secure a subscription from the librarian and have it forwarded to the Secretary. Please do not delay, but do it now.

L. R. JONES
C. L. SHEAR
R. A. HARPER

REPORT OF THE SEVENTH ANNUAL MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

The seventh annual meeting of the Society was held in the Botany and Zoology Building of the University of Ohio, Columbus, Ohio, December 28–31, in conjunction with the American Association for the Advancement of Science.

About fifty members were present and a program of sixty-eight papers was presented. The abstracts appeared in the last number of PHYTOPATHOLOGY. Twenty-five new members were elected, making a total of three hundred and thirty-five.

Joint sessions were held with Section G of the American Association for the Advancement of Science and with the Botanical Society of America.

The following officers were elected:

President, Dr. Erwin F. Smith, U. S. Department of Agriculture, Washington, D. C.

Vice President, Dr. Mel. T. Cook, New Jersey Agricultural Experiment Station, New Brunswick, N. J.

Secretary-Treasurer for three years, Dr. C. L. Shear, U. S. Department of Agriculture, Washington, D. C.

Councilor for three years, Dr. F. D. Kern, Pennsylvania State College, State College, Pa.

Councilor for one year, Dr. E. C. Stakman, College of Agriculture of the University of Minnesota, St. Paul, Minn., to fill the unexpired term of Dr. Mel. T. Cook.

One of the Chief Editors of PHYTOPATHOLOGY for three years, Dr. W. A. Orton, U. S. Department of Agriculture, Washington, D. C.

Associate Editors, Prof. H. T. Güssow, Central Experimental Farm, Ottawa, Canada; Dr. C. W. Edgerton, State Experiment Station, Baton Rouge, La.; Dr. E. C. Stakman, University Farm, Saint Paul, Minn.; and Dr. V. B. Stewart, Cornell University, Ithaca, N. Y.

Business Manager of PHYTOPATHOLOGY, Dr. C. L. Shear.

The Society decided to hold its next annual meeting in New York City December 26–30, 1916, in conjunction with the American Association for the Advancement of Science.

INCORPORATION OF THE SOCIETY

In accordance with instructions from the Society at its Philadelphia meeting, the Secretary secured the two other members required, Dr. W. A. Orton and Dr. Neil E. Stevens, and took out articles of incorporation for the Society under the laws of the District of Columbia. These articles are as follows:

Articles of Incorporation

City of Washington, District of Columbia:

We, the undersigned,

C. L. Shear, Vienna, Va.
W. A. Orton, Washington, D. C.
N. E. Stevens, Washington, D. C.

being persons of full age, and citizens of the United States and a majority being citizens of the District of Columbia, pursuant to and in conformity with Sections 599–604 of the Code of Law for the District of Columbia, enacted by the Senate and House of Representatives of the United States of America in Congress assembled, and approved March 3, 1901, hereby associate ourselves together as a body corporate, and certify in writing:

1. That the name of the body corporate is The American Phytopathological Society.

2. That the term for which the Society is organized is perpetual.

3. That the particular business and objects of the Society are to promote investigation and advancement in plant pathology and cooperation among plant pathologists, to hold meetings for the presentation and discussion of the results of research and investigation, to exchange ideas and experiences and consider methods and means of promoting research, to stimulate and encourage the members, to cooperate in all practical ways with other scientific organizations and agencies for the advancement of science and to publish and encourage the publication of contributions to plant pathology.

4. That the affairs, funds and property of the Society shall be in charge of a council of seven members: the President, Vice President, Secretary-Treasurer, retiring President, Chief Editor of PHYTOPATHOLOGY, and two members, one elected each year.

WITNESS our hands and seals, October 25, 1915.

Witness:
CHARLES BROOKS,
as to all.

C. L. SHEAR (*Seal*)
W. A. ORTON (*Seal*)
N. E. STEVENS (*Seal*)

DISTRICT OF COLUMBIA, SS:—

I, W. Spencer Armstrong, a Notary Public in and for said District, do hereby certify that C. L. Shear, W. A. Orton, and N. E. Stevens, parties to, and personally well known to me to be the persons who executed the annexed Articles of Incorporation, dated October 25, 1915, personally appeared before me in said District and acknowledged the same to be their act and deed.

TAKEN and certified by me under my hand and Notarial Seal this 25th day of October, 1915.

W. SPENCER ARMSTRONG,
Notary Public, D. C.

(10c. Int. Rev. Stamp affixed)
(*Notarial Seal*)

OFFICE OF THE RECORDER OF DEEDS,
District of Columbia.

This is to Certify that the foregoing is a true and verified copy of the Articles of Incorporation of The American Phytopathological Society of and the whole of said Articles of Incorporation as filed in this Office, the 25th day of October, A. D. 1915.

IN TESTIMONY WHEREOF, I have hereunto set my hand and affixed the seal of this Office this 25th day of October, A. D. 1915.

R. W. DUTTON,
Recorder of Deeds, D. C.

(10c. Int. Rev. Stamp affixed)
Recorder of Deeds
District of Columbia

Minutes of Meeting of Incorporators of the American Phytopathological Society

A meeting of Messrs. Shear, Orton, and Stevens, signers of articles of incorporation of The American Phytopathological Society, Incorporated, was held in Washington, D. C., October 25, 1915.

A temporary organization was effected, with W. A. Orton, Chairman, and C. L. Shear, Secretary.

The constitution and by-laws of The American Phytopathological Society as now standing were adopted.

Present members of the Society were elected members of the corporation, with their present rights and privileges.

The meeting adjourned to assemble at Columbus, Ohio, December 28, 1915.

C. L. SHEAR,
Secretary

REPORT OF COMMITTEES

The Committee on Common Names of Plant Diseases, consisting of F. C. Stewart, G. P. Clinton, F. L. Stevens, and E. M. Freeman presented the following report and the rules for the preparation of a list of common names:

After careful consideration of the various suggestions and criticisms submitted by members of the Society the Committee on Common Names recommends that the following rules be observed in the preparation of a list of the common names of plant diseases:

1. Names already in wide use shall not be changed except for urgent reasons.

2. As far as possible the name used shall be one which is descriptive of the characteristic symptoms produced in the host.

3. Diseases not coming under Rule 1 or Rule 2 may be named after the causal organism; examples Rhizoctoniose, Armillaria root-rot; but long, clumsy names should be avoided.

4. In general the various diseases caused by an organism on its different hosts shall bear the same common name, but this rule shall give precedence to Rule 1 and sometimes also to Rule 2.

5. An attempt shall be made to provide common names for all common and important diseases of the principal cultivated plants in the United States and Canada.

6. In addition to fungous and bacterial diseases, the list may include non-parasitic diseases and those of unknown origin, but not diseases caused by insects or animals.

7. Names of diseases caused by fungi and bacteria shall be followed in the list by the Latin name of the causal organism, non-parasitic diseases by "non-par.," and diseases of unknown origin by "undet." The name of each disease shall be followed by one or more bibliographic references which shall be selected with regard to—

(a) Accuracy and completeness of the description.

(b) Accessibility of the publication.

(c) Priority of publication.

(d) Language, American references being given preference.

8. The order of arrangement of hosts and of diseases under each host shall be alphabetical.

9. No common name shall be adopted unless approved by all five members of the Committee on Common Names.

10. From the choice of scientific names select the one which common usage and critical investigation have shown to belong to its mature stage.

It will be observed that the most important difference between this set of rules and the one submitted to the Society a year ago is found in Rule 10. It should be borne in mind that the proposed list is official only in respect to the *common* names and these only should be considered by the Society in voting on the adoption of the list. If it is deemed advisable for the Society to take official action on the *scientific* names used, a special committee should be appointed to consider the matter.

A partial list, including the diseases of hosts from alfalfa to cabbage, inclusive, is submitted herewith. Before proceeding further the Committee wishes to know whether the plan exemplified in this partial list meets with the approval of the Society. It is the sense of the Committee that the first list adopted should be considered only preliminary to a complete list to be prepared a few years hence.

The report and rules were adopted, and the Committee was directed to send to each member of the Society for criticism and suggestions the preliminary list of common names which it had prepared.

Some changes were made in the Committee, which now consists of F. C. Stewart, Chairman, G. P. Clinton, F. L. Stevens, E. C. Stakman, and W. A. Orton.

The Committee on Ways and Means, consisting of F. C. Stewart, C. L. Shear, D. Reddick, H. H. Whetzel, and L. R. Jones, reported that they had endeavored to secure an endowment for PHYTOPATHOLOGY, but thus far without success. It is considered desirable, however, to continue efforts in this direction, which it is hoped will finally be successful.

To meet the present needs of the Journal and to provide for the immediate future the Committee recommended that as many as possible of the members agree to pledge themselves to pay one hundred dollars in annual payments of ten dollars each and thus become sustaining life members of the Society.

The report of the Committee and the proposed plan were adopted, and over forty of the members present pledged themselves as sustaining life members.

At its request the Committee was discharged and the following new Committee appointed: L. R. Jones, Chairman, C. L. Shear, C. W. Edgerton, H. S. Jackson, and J. T. Barrett.

The Committee on Bibliography, consisting of L. R. Jones, C. L. Shear, and R. A. Harper, reported that through the assistance of Miss Oberly, Librarian of the Bureau of Plant Industry, U. S. Department of Agriculture, estimates from Williams & Wilkins Company had been obtained as to the cost of publishing the index of Pan-American phytopathological literature in the form of a card index, with three cards for each title. It was found that if subscriptions for fifty sets could be guaranteed the following price could be obtained: Back numbers for 1914 and 1915, $26; yearly subscription for current year, $12.50. A subscription blank was sent to each member and also to various libraries, but only about twenty-five subscriptions have been received.

The report of the Committee was adopted and the Committee continued. It was suggested that as the cost of these cards is greater than most of the members would care to assume that each member who is connected with an institution maintaining a library should make a special effort to secure a subscription from the library. It is hoped that each member will take this matter up at once in order that the necessary subscriptions may be obtained and arrangements made to issue the cards as soon as possible.

The Committee on the Schweinitz Collection of Fungi, consisting of C. L. Shear, J. C. Arthur, and A. G. Johnson, reported that it had corresponded with the Curator of the Academy of Natural Sciences of Philadelphia and had been assured that the authorities would be glad to adopt such suggestions as the Committee might make in regard to the more secure protection of the Schweinitz herbarium.

The report was adopted and the Committee continued.

The Committee on Bibliographical Index to North American Fungi originally consisted of Dr. Charles E. Bessey, with power to appoint associates. On Dr. Bessey's death Dr. Geo. T. Moore was requested to take charge of the matter. Doctor Moore reported that the chief reasons for the delay in the appearance of Dr. Farlow's index were the great amount of time and labor required in preparing the work and the difficulties connected with synonomy and nomenclature. The report was accepted.

The Committeee on Institutional Standardization, H. S. Reed, Chairman, made a report of progress and asked that the Committee be continued. The report was accepted and the Committee continued.

The Committee on Organization and Affiliation of Branches of the Society, consisting of Haven Metcalf, C. L. Shear, Wm. T. Horne, H. S. Reed, and H. S. Jackson, unanimously recommended the adoption of the following provisions for the organization and regulation of branch societies:

1. Branch societies shall elect to full membership only members of the American Phytopathological Society, but each branch society may elect associate members under such rules as it may adopt.

2. Branch societies which are established on a geographical basis shall be known as Divisions, and shall use the name of the parent society with the appropriate geographical term: For example, "American Phytopathological Society, Pacific Division."

3. The proceedings of Divisions shall always be printed in PHYTOPATHOLOGY. The preliminary abstracts of the Division meetings may at the discretion of these Divisions be printed in PHYTOPATHOLOGY upon the same terms as the abstracts of the American Phytopathological Society, i.e., at the expense of these Divisions. This rule, however, shall not be interpreted as limiting the present right of the Editorial Board of PHYTOPATHOLOGY to define the character and amount of any manuscript presented for publication.

4. Whenever the American Phytopathological Society meets within the territory of a Division the Division shall merge its program with that of the parent Society. The scientific sessions of such a meeting shall be presided over alternately by the president of the American Phytopathological Society and the president of the Division. Business sessions may be independent.

5. The constitutions or articles of organization of all Divisions shall contain a provision or provisions ratifying the above rules. The constitutions of all Divisions shall contain nothing in conflict with the constitution of the American Phytopathological Society. With the exceptions defined by the above rules the Divisions shall enjoy complete autonomy.

These rules were adopted by the Pacific Division at the Berkeley meeting of the Society.

The report of the Committee was accepted and the rules unanimously adopted by the Society.

The Committee on a Pure Culture Supply Laboratory, consisting of C. L. Shear,

L. R. Jones, and G. P. Clinton, reported that the matter had been taken up with the Chief of the Bureau of Plant Industry and various heads of offices, and that it had reason to hope that provision could be made for establishing this work, in a preliminary way at least, during the coming year.

The report was adopted and the Committee continued. Resolutions were also adopted requesting the authorities of the Department of Agriculture to give this matter favorable consideration if possible.

The Committee on Summer Meetings, consisting of Paul Murphy, E. C. Stakman, and D. Reddick, presented the following report:

The Committee, having considered the subject carefully, has come to the conclusion that summer meetings are desirable.

Two alternatives were considered, namely, in the first place, a single general gathering, and in the second place sectional gatherings of phytopathologists interested in special crops.

The Committee is of the opinion that a single general gathering is impracticable for several reasons. In the first place the distances which most members would have to travel would be too far, particularly at a time when the pressure of work is greatest. Besides it would be difficult to find an area in which there would be a sufficient variety of crops to satisfy the special requirements of all present. Further, a general meeting would naturally resolve itself into several sections, those interested in the diseases of any one group of crops having a natural tendency to segregate themselves.

The Committee is therefore of opinion that it would be more practicable for those interested in special lines, such as diseases of cereals or those of potatoes, to meet separately. It considers further, since most of the members would not have time or opportunity to travel very far, that the country should be divided into several sections which are natural units in virtue of climate, soil, geographical position or nature of crops raised. An example of such a section would be the most eastern seed-potato-raising States, including the Maritime Province of Canada. Another would be the cereal section of the upper Mississippi. The course recommended is that those interested in potato diseases in the northeastern section, for example, if they see fit, should meet at a convention place, say in Maine, all arrangements to be made by themselves of course. It is not necessary or even desirable that the number attending should be large.

The Committee considers that the gatherings should be quite informal. The only organization that would be required would be that a member, who might be called the Chairman, would invite by letter all those likely to attend, and generally supervise the arrangements. It would be desirable for those members from any particular section who are interested in the same line of work to informally appoint a Chairman at the Annual Meeting. In the absence of this step the members of the Committee might act in their respective sections for their co-workers who specialize on the same group of crops.

The initiative for organizing summer meetings would rest with the members of any section, but the Committee considers that immediate action would be profitable in many cases.

TREASURER'S REPORT

Receipts

Balance from 1914		$509.06	
Dues for—			
10 members 1913 and 1914	$30.00		
281 members for 1915	843.00		
1 life member	50.00	923.00	
Exchange from 8 members		1.25	
Dr. Farlow's gift to Society		50.00	
Patron's fee from M. L. Delafield, Jr		100.00	
Interest December, 1914, to November, 1915, inclusive		13.59	$1,596.90

Expenditures

Printing, postage, etc	$66.50	
Printing abstracts	73.51	
Traveling expenses	162.47	
Members' subscriptions to PHYTOPATHOLOGY	584.00	
Clerical work	33.10	
Exchange on two Canadian checks	.27	
Miscellaneous	21.41	941.26
Balance		$655.64

FINANCIAL STATEMENT OF BUSINESS MANAGER OF PHYTOPATHOLOGY[1]

Receipts

Balance from 1914	$120.71	
Williams & Wilkins subscriptions and sales	781.66	
Sales back numbers and reprints direct	71.26	
Subscriptions 292 members American Phytopathological Society	584.00	
American Phytopathological Society appropriation	200.00	
Interest December, 1914, to November, 1915, inclusive	1.94	1,759.57

Expenditures

Balance due Williams & Wilkins from 1914	$127.64	
Williams & Wilkins, mfg. PHYTOPATHOLOGY, Vol. V:		
No. 1	$426.22	
No. 2	177.81	
No. 3	318.80	
No. 4	146.02	
No. 5	170.97	
No. 6 (bill incomplete) paid	200.00	1,439.82

[1] When the $150.00 guarantee from advertising is received and the other bills for 1915 paid there will be a balance of about $60.00.

These accounts were referred to an Auditing Committee, consisting of W. J. Morse, E. C. Stakman, and P. J. Anderson, by which they were examined and approved. The report of the Committee was adopted by the Society.

Brought forward		$1,759.57
Williams & Wilkins, miscellaneous	$53.00	
L. R. Jones editorial work, etc	15.25	
American Phytopathological Society for Eastham dues paid Williams & Wilkins	3.25	
Hartig plate	30.00	
Clerical work $31.70, stationery 60c	32.30	
Reddick, D., postage and expressage	5.00	
Williams & Wilkins, insurance	5.40	1,711.66
Balance		$47.91

RESOLUTIONS ADOPTED

Resolved, That the American Phytopathological Society heartily endorses the House of Representatives bill No. 528, entitled A Bill to discontinue the use of the Fahrenheit thermometer scale in Government publications and adopt instead the Centigrade scale of temperature measurements.

WHEREAS, This Society recognizes the great and increasing value of the Experiment Station Record as a scientific review journal; and

WHEREAS, It would add much to its value if it contained the original titles of all articles abstracted; be it therefore—

Resolved, That the American Phytopathological Society respectfully urges the importance of this matter upon the attention of the Honorable Secretary of Agriculture and the Editors of the Experiment Station Record in the hope that they may find it practicable so to handle future publications.

The Society lost two members, Dr. C. E. Bessey and Dr. W. Ralph Jones, by death during the year. The following statement and resolution were adopted unanimously by the Society and copies sent to the relatives of the Deceased:

Dr. Charles E. Bessey was a charter member of the Society and one of the oldest and best-known botanists in this country. He was also the beloved and respected teacher of many of the members of the Society. Dr. W. Ralph Jones was a scientific assistant in pathology in the Bureau of Plant Industry and a young man of unusual ability and promise as an investigator.

Resolved, That the Society hereby expresses its deep sense of loss in the death of these members, and believes that the greatest tribute to their memory is the record of the work which they have accomplished.

Upon invitation from the Second Pan American Scientific Congress President Whetzel appointed W. A. Orton Delegate and C. L. Shear Alternate Delegate to represent the Society. The Council submitted through its Delegates the following resolution to the Congress:

Resolved, That there be appointed by the Congress a permanent Committee on Pan American Plant Pathology, to be composed of specialists from all participating countries, to consider all matters relating to the occurrence and spread of plant diseases, the promotion of research and discovery of control measures, the development of closer and more intimate international scientific relations, cooperation in plant disease surveys, plant quarantine, and other problems of mutual interest; also to urge the establishment as a branch of the Pan American Union of a central Bureau for the promotion of the above-named objects.

The Society unanimously approved of this resolution and sent a telegram offering greetings to the Congress and urging favorable action on the resolution.

In view of the great value of definite knowledge and available record of the occurrence and distribution of the parasitic diseases of cultivated plants in the United States and the probability that such diseases will increase, be it—

Resolved, That the American Phytopathological Society respectfully requests The Honorable Secretary of Agriculture to provide for the publication of the results of the plant-disease surveys of the several States from the data already available and in such form as to admit of the use of these results by all collaborators, investigators, and teachers of Phytopathology, and also to arrange for the reissue of such publication at such intervals as seem desirable; and further—

Resolved, That a copy of these resolutions be sent to The Secretary of Agriculture.

Resolved, That the Society expresses its deep appreciation and thanks to the Local Committee and the members of the Department of Botany of the University of Ohio for the excellent facilities provided and for the many courtesies extended during this meeting.

MISCELLANEOUS BUSINESS

Upon motion the Society voted to appropriate two hundred dollars or such part thereof as necessary towards the support of PHYTOPATHOLOGY for 1916.

Upon motion it was voted to approve of the action of the Council during the year in authorizing the payment of expenses of the Secretary to attend the Berkeley meeting; also the authorization of the Council permitting the Business Manager of PHYTOPATHOLOGY to expend such amount as necessary to provide clerical assistance, and such other ad interim acts as the Council had found it necessary to perform.

The question of continuing the present plan of publishing abstracts was thoroughly discussed at a smoker held by the Society Thursday evening, December 30. Various arguments, both pro and con, were presented. At the business session Friday morning, December 31 it was voted to continue the printing of abstracts for use at the meetings. The Secretary was instructed not to receive abstracts after December 1, and not to accept those containing over two hundred words, and members were requested to restrict them to one hundred words whenever possible. Members were also advised if they do not expect to attend the meeting to submit their abstracts in the form of notes for publication under this head in the JOURNAL.

In view of the scarcity of back numbers, it was decided to raise the price of back volumes of PHYTOPATHOLOGY to five dollars each beginning July 1, 1916, and of single numbers to eighty-five cents each. Since the selling of single numbers of back volumes frequently breaks up sets of the JOURNAL and causes much loss no odd back numbers will be sold after July 1 unless they occur in volumes already broken.

On account of the loss of numbers of the JOURNAL sent to delinquent members the Secretary was instructed to send out bills for dues in November hereafter and to withhold the JOURNAL from those whose dues have not been received by January 15.

Owing to the great risk of loss in forwarding copies of PHYTOPATHOLOGY to Europe under present conditions it is necessary that all such copies be sent at the subscribers' risk, and lost numbers can not be supplied free. If desired subscribers may have their copies held for them until such time as they may desire to have them for-

warded. It was also decided to allow sixty days hereafter for forwarding notice of missing numbers.

In view of the great assistance given by Miss Oberly in the preparation of the list of literature for the JOURNAL the Business Manager was authorized to supply the Library of the Department of Agriculture with a free copy of PHYTOPATHOLOGY, and also with a set of the Index Cards to Literature when published.

C. L. SHEAR,
Secretary-Treasurer

LITERATURE ON AMERICAN PLANT DISEASES[1]

COMPILED BY MISS E. R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY

December, 1915 to January, 1916

Arthur, Joseph Charles, and **Fromme, Fred Denton.** New species of grass rusts. Torreya **15,** no. 12: 260–265. December, 1915.

Babcock, D. C. Potato diseases and seed potatoes. Ohio Agr. Expt. Sta. Mo. Bul. **1,** no. 1: 10–14, illus. January, 1916.

Barrus, Mortier Franklin. An anthracnose-resistant red kidney bean. Phytopathology **5,** no. 6: 303–311, 4 fig. December, 1915.

Colletotrichum lindemuthianum.

Bartholomew, Elbert T. A pathological and physiological study of the black heart of potato tubers. Centbl. Bakt. [etc.] II, **43,** No. 19/24: 609–639, 3 pl. (1 col.). Juni 4, 1915.

Literature cited, p. 637–638.

Bartram, H. E. Effect of natural low temperature on certain fungi and bacteria. Jour. Agr. Research **5,** no. 14: 651–655. January 3, 1916.

Bioletti, Frederic T. Control of Oidium or vine mildew. California Cult. **46,** no. 2: 40–41, 58. January 13, 1916.

——— and **Flossfeder, F. C. H.** Oidium or powdery mildew of the vine. California Agr. Expt. Sta. Circ. 144, 12 p., 7 fig. 1915.

Boncquet, P. A., and **Hartung, W. J.** The comparative effect upon sugar beets of Eutettix tenella Baker from wild plants and from curly top beets. Phytopathology **5,** no. 6: 348–349, 1 fig. December, 1915.

Burrill, A. C. Insect control important in checking fire blight. Phytopathology **5,** no. 6: 342–347. December, 1915.

Literature cited, p. 347.

Bacillus amylovorus.

Canada. Department of Agriculture. Division of Botany. Regulations under the destructive insect and pest act governing the importation, sale, shipment and exportation of the common or Irish potato (Solanum tuberosum L.). Canada Dept. Agr. Expt. Farms Div. Bot. Farmers' Circ. 6, 14 p. 1914.

Cardin, Patricio. Informe del departamento de patologia vegetal y entomologia. Cuba Estac. Expt. Agron. 3d Informe An. **1909/14**: 98–173, 5 pl. 1915.

Cook, Melville Thurston. The pathology of ornamental plants. Bot. Gaz. **61,** no. 1: 67–69. January, 1916.

[1] This list aims to include the publications of North and South America, the West India Islands, and islands controlled by the United States, and articles by American writers appearing in foreign journals.

All authors are urged to coöperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

Coons, George Herbert. Factors involved in the growth and the pycnidium formation of Plenodomus fuscomaculans. Jour. Agr. Research **5**, no. 16: 713–769. January 17, 1916.

Literature cited, p. 766–769.

Dodge, Bernard Ogilvie. The effect of the host on the morphology of certain species of Gymnosporangium. Bul. Torrey Bot. Club **42**, no. 9: 519–542, pl. 28–29. September, 1915.

Eastham, John William. Powdery scab of potatoes (Spongospora subterranea (Wallr.) Johns.) Canada Dept. Agr. Expt. Farms Div. Bot. Farmers' Circ. 5, 13 p., illus. 1914.

Edgerton, Claude Wilbur. A new method of selecting tomatoes for resistance to wilt disease. Science n. s. **42**, no. 1095: 914–915. December 24, 1915.

Fusarium lycopersici.

——— Seed bed sanitation. Louisiana Agr. Col. Ext. Div. Circ. 9, 16 p., illus. 1915.

Fawcett, Howard S. Citrus diseases of Florida and Cuba compared with those of California. California Agr. Expt. Sta. Bul. 262: 149–210, 24 fig. 1915.

Garman, Harrison. How to avoid potato scab and dry rot. Kentucky Agr. Expt. Sta. Newspaper Bul. 82, 1 p. 1914.

"(1) The selection of sound seed, (2) treatment with formalin or corrosive sublimate, and (3) rotation, are the means by which both of these pests may be avoided."

——— Twig blight and pear blight. Kentucky Agr. Expt. Sta. Circ. 2, 8 p., 4 fig. 1915.

Bacillus amylovorus.

Gilbert, A. H., and **Myer, D. S.** Stem rot of clovers and alfalfa as a cause of "clover sickness." Kentucky Agr. Expt. Sta. Circ. 8: 45–60, illus. 1915.

Sclerotinia trifoliorum Erik.

Grossenbacher, John Gasser. Citrus pests and diseases. When and with what to spray for them. Florida Grower **13**, no. 2: 11–12. January 12, 1916.

——— Some bark diseases of citrus trees in Florida. Florida Grower **13**, no. 2: 7–9, 18–19, 7 fig. January 8, 1916.

Güssow, Hans Theodor. Report of the division of botany. Canada Expt. Farms Rpts. [**1913**]/**14**, 2: 831–838. 1915.

Harter, Leonard Lee. Sweet-potato scurf. Jour. Agr. Research **5**, no. 17: 787–791, pl. 57–58. January 24, 1916.

Monilochaetes infuscans.

Heald, Frederick De Forest, and **Studhalter, Richard Arthur.** Seasonal duration of ascospore expulsion of Endothia parasitica. Amer. Jour. Bot. **2**, no. 9: 429–448, 6 fig. November, 1915.

Literature cited, p. 447–448.

——— and **Woolman, H. M.** Bunt or stinking smut of wheat. Washington Agr. Expt. Sta. Bul. 126, 24 p., 5 fig. 1915.

Tilletia tritici or *Tilletia foetans.*

Hotson, John William. Fire blight on cherries. Phytopathology **5**, no. 6: 312–316, pl. 14. December, 1915.

Bacillus amylovorus.

Humphrey, Clarence John, and **Fleming, Ruth Mary Bates.** Toxicity of various wood preservatives. Jour. Indus. and Engin. Chem. **6**, no. 2: 128–131, February, 1914; **7**, no. 8: 652–658, illus., August, 1915.

Jehle, Robert Andrew. El tizon tardio y la pudricion de la papa. Cuba Estac. Expt. Agron. Circ. 48, 6 p., 6 fig. 1915.
Phytophthora infestans.

Johnston, John Robert. La enfermedad del platano en Cuba. Cuba Estac. Expt. Agron. Circ. 47, 13 p., 7 pl. 1915.

Jones, Lewis Ralph, and **Bartholomew, Elbert T.** Apple rust and its control in Wisconsin. Wisconsin Agr. Expt. Sta. Bul. 257, 30 p., 14 fig. 1915.
Literature, p. 29–30.

——— and **Gilman, J. C.** The control of cabbage yellows through disease resistance. Wisconsin Agr. Expt. Sta. Research Bul. 38, 70 p., 23 fig. 1915.
Literature cited, p. 69–70.
Fusarium conglutinans.

Kezer, Alvin. Treatment of seed grain to prevent smut. Colorado Agr. Expt. Sta. Press Bul. 49 (ed. 2), 4 p. 1915.

Long, William Henry. A honeycomb heart-rot of oaks caused by Stereum subpileatum. Jour. Agr. Research **5**, no. 10: 421–428, pl. 41. December 6, 1915.

Lutman, Benjamin Franklin. The combat with plant disease. 6th Ann. Rpt. Com. Agr. Vermont **1913/14**: 108-112. 1914.

Lyman, George Richard, and **Rogers, John Terrell.** The native habitat of Spongospora subterranea. Science n. s. **42**, no. 1096: 940–941. December 31, 1915.
Discovery of fungus on potatoes from Peru.

Meinecke, Emilio Pepe Michael. Peridermium harknessii and Cronartium quercuum. Science n. s. **43**, no. 1098: 73. January 14, 1916.

Melchers, Leo Edward. The grouping and terminology of plant diseases. Phytopathology **5**, no. 6: 297-302. December, 1915.

Meyer, Louis. To smudge or not to smudge. Country Life Amer. **29**: 37, illus. November, 1915.

Morris, O. M. Winter injury of fruit trees more common in northwest. Better Fruit **10**, no. 6: 19–21. December, 1915.

Morse, Warner Jackson. Some diseases of the potato. 13th Ann. Rpt. Com. Agr. Maine **1914**: 346–361, 14 pl. 1915.

Nowell, William. New light on the witch-broom disease of cacao. Agr. news [Barbados] **14**, no. 354: 382. November 20, 1915.
Marasmius perniciosus.

——— A stem disease of sugar-cane in Barbados. Agr. News [Barbados] **15**, no. 357: 14. January 1, 1916.
Cephalosporium sacchari.

O'Gara, Patrick Joseph. A fungus of uncertain systematic position occurring on wheat and rye. Science n. s. **43**, no. 1099: 111–112. January 21, 1916.

——— A Phoma disease of western wheat-grass. Science n. s. **43**, no. 1099: 110–111. January 21, 1916.

——— A Podosporiella disease of germinating wheat. Phytopathology **5**, no. 6: 323–326, pl. 15–16. December, 1915.
Podosporiella verticillata sp. nov.

Orton, Clayton Roberts, and **Adams, J. F.** Collar-blight and related forms of fire blight. Pennsylvania Agr. Expt. Sta. Bul. 136, 23 p., 13 fig. 1915.
Bacillus amylovorus.

Petch, Thomas. Citrus mildew. Phytopathology **5**, no. 6: 350–352. December, 1915.

Reddick, Donald, and **Crosby, C. R.** Dusting and spraying experiments with apples. New York Cornell Agr. Expt. Sta. Bul. 369: 305–356, fig. 70–84. 1916.

Rees, H. L. Always hill select potato seed. West. Washington Agr. Expt. Sta. Mo. Bul. **3**, no. 5: 8–11, illus. August, 1915.

——— Experimental spraying for blackberry anthracnose. West. Washington Agr. Expt. Sta. Mo. Bul. **3**, no. 8: 2–10, illus. November, 1915.

——— Late blight of celery. West. Washington Agr. Expt. Sta. Mo. Bul. **2**, no. 11: 11–18, fig. 5–8. February, 1915.

Robbins, Wilfred W., and **Reinking, Otto A.** Fungous diseases of Colorado crop plants. Colorado Agr. Expt. Sta. Bul. 212, 54 p., 19 fig. 1915.

Rosenbaum, Joseph. Phytophthora disease of ginseng. New York Cornell Agr. Expt. Sta. Bul. 363: 61–106, fig. 2–18. 1915.

São Paulo. Secretaria da Agricultura, Commercio e Obras Publicas. Mildiow. Bol. Agr. [São Paulo] **16**, no. 10: 836–845, Outubro; no. 11: 921–936, 4 fig., Novembro. 1915.

Selby, Augustine Dawson, Houser, True, and **Humbert, J. G.** How to disinfect tobacco plant beds from root-rot fungus, (Thielavia). Ohio Agr. Expt. Sta. Circ. 156: 5–8, 1 fig. 1915.

Smith, Elizabeth Hight. Pythiacystis infection of deciduous nursery stock. Phytopathology **5**, no. 6: 317–322, 4 fig. December, 1915.

Smith, Erwin Frink, and **Bryan, Mary Katherine.** Angular leaf-spot of cucumbers. Jour. Agr. Research **5**, no. 11: 465–476, pl. 43–49. December 13, 1915.

Bacterium lachrymans, sp. nov.

Smith, Ralph Elliott, and **Boncquet, P. A.** Connection of a bacterial organism with curly leaf of the sugar beet. Phytopathology **5**, no. 6: 335–342, 1 fig., pl. 17. December, 1915.

?Bacillus dianthi.

Stevens, H. E. Citrus canker—III. Florida Agr. Expt. Sta. Bul. 128, 20 p., 6 fig. 1915.

Pseudomonas citri.

Stewart, Alban. An anatomical study of Gymnosporangium galls. Amer. Jour. Bot. **2**, no. 8: 402–417, 1 fig. October, 1915.

Summary of literature cited, p. 415–416.

Stewart, Vern Bonham. Mildew on black currants. Phytopathology **5**, no. 6: 349. December, 1915.

?Sphaerotheca mors-uvae.

——— Notes on the fire blight disease. Phytopathology **5**, no. 6: 327–334. December, 1915.

Bacillus amylovorus.

U. S. Department of Agriculture. Federal Horticultural Board. Report [**1914**] **15**, 11 p. 1915.

——— ——— Service and regulatory announcements. September: 59–79, October 30; October: 81–86, 1 fig., December 4; November: 87–90, December 23. 1915.

U. S. Department of Agriculture. Bureau of Plant Industry. Report of the chief [**1913**]/**14**, 28 p., 1914; [**1914**]/**15**, 16 p., 1915.

Pathological investigations, [**1913**]/**14**, p. 2–6.

Plant pathological investigations, [**1914**]/**15**, p. 3–5.

Waldron, Ralph A. Physiological studies on the chestnut blight disease. Pennsylvania Agr. Expt. Sta. Ann. Rpt. **1912**/**13**: 152–156, illus. 1914.

Bibliography, p. 155–156.

Endothia parasitica.

Weir, James Robert, and **Hubert, Ernest Everett.** A serious disease in forest nurseries caused by Peridermium filamentosum. Jour. Agr. Research **5**, no. 17: 781–785. January 24, 1916.

Wilson, James K. Calcium hypochlorite as a seed sterilizer. Amer. Jour. Bot. **2**, no. 8: 420–427. October, 1915.
Bibliography, p. 426–427.

Woods, Charles D. Plant pathology. Maine Agr. Expt. Sta. Spec. Rpt. **1913**: 43–59. [1914.]

——— Powdery scab of potatoes. Maine Agr. Expt. Sta. Spec. Rpt. **1914**: 26–33. 1915.

[PHYTOPATHOLOGY, for February, 1916 (1: 1–126, Pls. I–IV), was issued February 9, 1916.